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NOTES ON THE ORIENTAL MIGRATORY LOCUST (*LOCUSTA MIGRATORIA MANILENSIS* MEYEN) WITH SPECIAL REFERENCE TO ITS SOLITARY PHASE AND BREEDING PLACE OR OUTBREAK AREA[1]

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FOUR PLATES

In 1927, the writer called attention to Uvarov's phase theory, propounded by him in 1921, and pointed out its practical application to the control of the migratory locust in the Philippines. Since then several papers by local authors (Gonzales, 1932; Otanes, 1931 and 1939; Goseco, 1933; and Uichanco and Gines, 1937) have appeared from time to time in which they make use of the phase theory in connection with their data or observations. In other countries, among the investigators whose works have thrown much light on the phase theory, besides Uvarov, are Faure (1932) of South Africa, Zolotarevsky (1929) of Madagascar and Johnston (1926) of Sudan. According to this theory, all migratory locusts have three main phases in their development, namely, *solitaria*, *transiens* and *gregaria* or *migratoria*, which differ more or less in appearance and habits. The phase *transiens* has been subdivided by Uvarov and Zolotarevsky (1929) into two, namely, *congregans* and *dissocians*. During periods when migratory swarms are not found, the species concerned exists as solitary insects which are practically harmless and live and behave like ordinary grasshoppers. When certain conditions obtain or as a response to certain un-

[1] Received for publication September 9, 1940.

usual conditions in the environment (Uichanco and Gines, 1937) these solitary forms multiply, the offspring forming loose swarms (phase *transiens*, subphase *congregans*) and eventually the greatly increased progeny become migratory both in appearance and habits. The scattered swarms of these combine or coalesce and the denser the numbers of the insects become the greater is the migratory impulse of the insects and migration then takes place resulting in the invasion of the populated and cultivated areas. When the swarms are greatly thinned out by natural factors and human efforts, the small swarms that are left break up and produce progeny of the phase *transiens* (subphase *dissocians*) and the development later culminates in the production of individuals of the solitary phase. The solitary individual insects may be considered then as the parents, as it were, of migratory swarms, the components of which differ markedly from the solitary individuals in certain respects, such as color, shape and size of certain parts of the body, etc., so that they have been formerly identified as distinct species. According to Uvarov (1936), the solitary phase is the normal state of the species which insures its perpetuation, while the gregarious or migratory phase arises as an inevitable physiological response of the species to unusual or violent fluctuations in the vital environmental factors, such as temperature, humidity, etc. In other words, the migratory phase is only temporary. Conditions in the breeding or outbreak areas of the species may so undergo such marked changes that migratory swarms are no longer developed but the species will continue to exist because of its solitary phase. The phase theory, then, as shown by the results of extensive investigations in other countries and to a certain extent in the Philippines, appears to explain in a satisfactory manner the appearance and disappearance and fluctuations of locust outbreaks.

FACTORS INFLUENCING AGGREGATION AND THE FORMATION OF MIGRATORY SWARMS

The factors that influence the breeding of the solitary forms of migratory locusts to swarms of the phase *transiens* and then these eventually to swarms of the phase *gregaria* or *migratoria* are believed to be chiefly climatic. Unusually prolonged droughts, for instance, which occur at long irregular intervals, are most commonly associated with the occurrence of swarm invasions or locust outbreaks. Available evidence tends to show

that locusts are highly sensitive to high temperature and low humidity and these conditions obtain for extended periods during droughts. It is believed that during such droughts the solitary forms of a migratory locust tend to congregate in restricted areas where the grass is green, such as in depressions, pockets or small valleys and along river and creek beds, etc., and their coming together stimulates breeding, and perhaps partly because of the relative scarcity of natural checks, such as parasites, these being believed to be more greatly adversely affected by droughts than the locusts themselves, the latter go on multiplying at an accelerated rate. The scattered swarms formed, as has been stated, tend to combine or coalesce and the denser the insects become, the greater the mating and the swarming instincts become, leading to the formation of migratory swarms, which leave the breeding or outbreak areas to invade cultivated and populated areas. The outbreak may persist for several or many years, reaching its peak at a certain year, and then begins to wane until no more migratory swarms are found.

In the Philippines, outbreaks of the Oriental Migratory Locust (*Locusta migratoria manilensis* Meyen) occur at irregular intervals, 7 to 13 years (the average being 10 to 11 years), according to the records of the old Bureau of Agriculture and the Bureau of Plant Industry since 1912 and the interval between outbreaks is one to two years. Thus, on July 28, 1917, it was reported by Hernandez (1919) that no known locust swarms existed in the Philippines. However, in 1918 slight infestations were reported, but it was not until 1919 when larger swarms, especially in Mindanao and Sulu, were reported. This 1919 outbreak gradually increased and reached its peak in 1922, when the number of municipalities infested increased from 60 to over 380. Since then, the infestation gradually decreased, and in 1929 the Philippines was officially declared free of locust. In 1930, slight infestations occurred in Davao, Mindoro, and Occidental Negros, but as was reported by Otanes (1931), the insects were not of the migratory phase but of the phase *transiens*. During 1931, more infestations of the phase *transiens* were reported but it was not until January, 1932 when dense migratory swarms appeared in Cotabato and by May, 1932 swarms had invaded not only other provinces in Mindanao but also Cebu, Bohol, Leyte, Negros, Panay, Samar, Masbate, etc. By June, 1939, the 1932 outbreak had come to an end, as no

more migratory swarm could be found. At this writing (July, 1940), slight infestations of the phase *transiens* have been reported from Cagayan, Mindoro, Isabela, and Occidental Negros. Basing upon the records and upon the appearance of these widely occurring infestations of the phase *transiens*, a new outbreak of migratory swarms may occur again between 1941 and 1943 (that is 10 to 11 years from 1932) or not very far beyond 1943.

THE SOLITARY AND OTHER PHASES OF THE ORIENTAL MIGRATORY LOCUST

In the Philippines, the phase *gregaria* of the Oriental Migratory Locust (*Locusta migratoria manilensis* Meyen) appears to have been well characterized biometrically by Uichanco and Gines (1937). Data, however, on the phase *solitaria* of this oriental species are lacking. In view of this, the writer deemed it timely to publish the following notes on the solitary phase of the Oriental Migratory Locust, preliminary to a more detailed paper on the studies that have been made further on the biology and control of said species.

In 1931, specimens of solitary locusts were collected from Cebu. Several of these were sent to Doctor B. P. Uvarov of the Imperial Bureau of Entomology, London, England, with the statement that similar specimens in the collection of the Bureau of Plant Industry were labeled as *Locusta australis* Saussure, which is regarded by him (Uvarov, 1928) as a phase of *Locusta migratoria*. Doctor Uvarov identified the specimens sent him as of the phase *solitaria* of the local migratory locust, then still known as *Locusta migratoria migratorioides* R. & F., now *Locusta migratoria manilensis* Meyen (Uvarov, 1936), with the remarks that the specimens showed some characters of transition to the swarming phase (phase *gregaria*).

In order to more definitely ascertain the characteristics of the locust collected from Cebu, in terms of ratios of the measurements of certain body parts, the remaining specimens, consisting of 7 males and 5 females, were measured. These measurements, as shown in table 1, gave as average ratios for the females 1.86 for E/F (ratio of tegmen or "elytron" to femur); 1.35 for P/C (pronotum to width of head); 1.26 for H/C (height of pronotum to width of head) and 0.92 for M/C (width of pronotum to width of head). The corresponding measurements for the males are 1.74 for E/F; 1.48 for P/C; 1.37 for H/C and 0.93 for M/C. The measurements were made in ac-

TABLE 1.—*Measurements of locusts*[1] *collected from a loose swarm in Cebu, October 15, 1931.*

Number	Sex	E	F	P	H	M	C	E/F	P/C	H/C	M/C
1	F	4.89	2.70	0.95	0.91	0.60	0.69	1.81	1.38	1.32	0.87
2	F	4.50	2.44	0.86	0.85	0.61	0.65	1.84	1.32	1.31	0.94
3	F	4.51	2.43	0.90	0.86	0.62	0.65	1.86	1.38	1.32	0.95
4	F	4.30	2.35	0.84	0.80	0.58	0.63	1.83	1.33	1.27	0.92
5	F	4.03	2.05	0.82	0.74	0.56	0.61	1.97	1.34	1.21	0.92
Totals		22.23	11.97	4.37	4.16	2.97	3.23				
Average ratios								1.86	1.35	1.26	0.92
1	M	3.40	2.00	0.75	0.70	0.46	0.48	1.70	1.56	1.46	0.96
2	M	3.47	1.98	0.76	0.66	0.47	0.50	1.75	1.52	1.32	0.94
3	M	3.90	2.20	0.80	0.73	0.51	0.56	1.77	1.43	1.30	0.91
4	M	3.57	1.94	0.73	0.68	0.48	0.52	1.84	1.40	1.31	0.92
5	M	3.23	1.88	0.69	0.69	0.43	0.49	1.73	1.41	1.41	0.88
6	M	3.25	1.90	0.74	0.70	0.45	0.48	1.71	1.54	1.46	0.94
7	M	3.36	1.96	0.72	0.65	0.46	0.48	1.72	1.50	1.35	0.96
Totals		24.18	13.86	5.19	4.81	3.26	3.51				
Average ratios								1.74	1.48	1.37	0.93

[1] Collected by A. G. Toquero of the Plant Pest and Disease Control Division, Bureau of Plant Industry, Manila.

cordance with the suggestions in the Proceedings of the Fourth International Locust Conference held at Cairo, Egypt, in April, 1936. For the benefit of local workers and fieldmen engaged in locust control work, who have no access to the Proceedings just referred to, the writer has reproduced the figure (plate I) showing the methods of measurement adopted. The average ratios were likewise figured in accordance with the suggestions in said Proceedings, namely, that the average ratios be obtained by calculating the ratios of the totals and not the average of the individual ratios.

With a pair of dividers and a ruler, preferably one that is calibrated to 0.5 millimeter, one may, by following the methods suggested here, ascertain definitely the phase characters of any adult locust specimens or of a given swarm by measuring specimens caught from such swarm and computing the average ratios of the different measurements so made and comparing them with the average ratios given in this paper for the different phases of the Oriental Migratory Locust. The value to fieldmen engaged in locust scouting and control of an up-to-date knowledge of the biology of the migratory locust, especially as regards its phases in the light of the results of studies here and abroad, cannot be overemphasized. Their ability to differentiate the phases in the field will add greatly to the accuracy of their reports and will thus help more effectively in the study of the biol-

ogy and ecology of the migratory locust, the results of which serve as a basis for a more intelligent warfare against the pest.

Uvarov's measurements (1936) of two specimens, one male and one female, collected from Nanking, China, together with average ratios from specimens of the phase *transiens*, are as follows:

	E/F	P/C	H/C	M/C
Phase *solitaria*				
Male	1.87	1.33	1.25	0.91
Female	1.92	1.53	1.31	0.92
Phase *transiens*				
Average for all specimens				
Male	1.83	1.25	1.19	0.86
Female	1.91	1.25	1.20	0.88
Average for Los Baños specimens				
Male	1.88	1.26	1.20	0.89
Female	1.92	1.22	1.20	0.89

Although Doctor Uvarov's measurements are based on a very limited number of specimens as he himself (1936) bewailed, yet they are the only data available for our species for the purposes of this paper. As stated, his figures for the phase *solitaria* were taken only from one male and one female collected from Nanking, China, in 1932. The phase *transiens* was better represented, specimens bred in cages in Los Baños, Laguna, sent by Doctor L. B. Uichanco, of the College of Agriculture, University of the Philippines, being among those studied by Doctor Uvarov. Other specimens of the phase *transiens* were from Nanking, China, Indo-China, Malaya, and Borneo. As to the phase *gregaria* Uvarov's likewise apparently limited number of specimens came from Nanking, China, and North Celebes. There was none from the Philippines. However, it may be stated in this connection that extensive biometrical measurements have been made by Uichanco and Gines and their results are presented in their recent paper (1937). These measurements were taken from numerous specimens most of which were collected by fieldmen of the Bureau of Plant Industry. These were collected from more or less dense swarms so that apparently they were chiefly of the phase *gregaria* or *migratoria* and the remarkably close agreement of the mean ratios obtained by Doctor Uichanco and Mr. Gines and those of Doctor Uvarov's data tend to confirm this statement. It may be said, therefore, that biometrically, the phase *gregaria* has been well characterized by the data obtained by these two authors. For the benefit

of local workers and for purposes of reference their mean ratios and those of Doctor Uvarov are given hereunder:

	E/F	P/C	H/C	M/C
Uvarov's data				
For phase *gregaria*				
Male	2.11	1.11	1.10	0.81
Female	2.16	1.11	1.08	0.83
Uichanco and Gines' data				
Male	2.14	1.10	1.01	
Female	2.20	1.09	1.01	

It may be noted from these measurements that the differences in the average E/F ratios (for all specimens) in the phases *transiens* and *solitaria* are not significant, the more so in the case of the average E/F ratio of the Los Baños *transiens* specimens. It is only in the ratios P/C, H/C and M/C that more or less significant differences obtain.

Comparing our average ratios for the Cebu lot with Doctor Uvarov's figures, the E/F ratios are nearer those of the phase *transiens*—especially so in the case of the female. However, as stated, the differences in the E/F ratios in both phases are not significant. The female also seems to be nearer the phase *transiens* with respect to the P/C ratio. But in the other ratios, P/C, H/C and M/C, the male specimens of the Cebu lot are predominantly *solitaria* in character, thus confirming the identification of Doctor Uvarov that the specimens from Cebu sent to him for study were of the phase *solitaria*, but showing characters of transition to the swarming phase, especially so in the case of the females. The males, however, are distinctly *solitaria* in character.

BREEDING PLACE OR OUTBREAK CENTER

These specimens from Cebu were collected in 1931 from a loose or thin swarm in a cultivated field—that is before the 1932 outbreak, which lasted until June, 1939. This outbreak, so far as the records of the Bureau of Plant Industry show, started in Cotabato, Mindanao. The accompanying map (plate 4) shows the general movement of locust swarms during the 1932–1939 outbreak, as based on field observations and on the reports of the fieldmen of the Bureau of Plant Industry and provincial and municipal officials. The shaded area indicates the probable outbreak areas of the Oriental Migratory Locust. Swarms reached only as far as the Provinces of Laguna and Batangas. The more extensive campaigns conducted may chiefly account

TABLE 2.—*Measurements of solitary locust specimens collected from different places and bred in the Entomology Laboratory at Singalong, Manila.*

(Most of the specimens were collected by A. G. Toquero)

No.	Place collected	Date	Sex	Measurements in centimeter						Ratios				Remarks
				E	F	P	H	M	C	E/F	P/C	H/C	M/C	
1	Lubao, Pampanga	Aug. 17, 1935	F	------	------	0.94	0.90	0.62	0.68	------	1.38	1.32	0.91	Brown. Femora missing.
2	Singalong, Manila	Sept. 9, 1935	F	4.85	2.90	1.05	1.00	0.65	0.72	1.67	1.46	1.39	0.90	Green. Caught in copula with male No. 1.
3	Singalong, Manila	March 19, 1936	F	4.85	2.78	0.98	0.96	0.65	0.70	1.74	1.40	1.37	0.93	Green.
4	Singalong, Manila	Aug. 25, 1937	F	4.95	2.81	1.02	0.95	0.65	0.70	1.76	1.46	1.36	0.93	Brown. Mated with male No, 2.
5	Bangued, Abra	Sept. 13, 1937	F	4.86	2.73	1.01	0.94	0.65	0.68	1.78	1.49	1.38	0.96	Green. Mated with male No. 3.
6	Bangued, Abra	Sept. 14, 1937	F	4.78	2.79	1.02	0.95	0.63	0.70	1.71	1.46	1.36	0.90	Brown. Mated with male No. 4.
7	Bangued, Abra	Sept. 20, 1937	F	4.92	2.82	1.00	0.95	0.66	0.72	1.75	1.39	1.32	0.92	Green. Mated with male No. 5.
8	Candon, Ilocos Sur	Sept. 22, 1937	F	4.90	2.82	1.02	0.92	0.66	0.69	1.74	1.48	1.33	0.96	Brown. Mated with male No. 6.
Totals				34.11	19.65	8.04	7.57	5.17	5.59					
Average ratios										1.74	1.44	1.35	0.92	

1	Singalong, Manila	Sept. 9, 1935	M	3.80	2.20	0.75	0.70	0.48	0.50	1.73	1.50	1.40	0.96	Green. Caught in copula with female No. 2
2	Singalong, Manila	Aug. 25, 1937	M	3.41	2.02	0.76	0.66	0.49	0.52	1.69	1.46	1.27	0.94	Green. Mated with female No. 4.
3	Bangued, Abra	Sept. 13, 1937	M	3.45	2.02	0.76	0.69	0.45	0.52	1.71	1.46	1.33	0.87	Green. Mated with female No. 5.
4	Bangued, Abra	Sept. 14, 1937	M	3.32	1.86	0.70	0.63	0.42	0.45	1.78	1.56	1.40	0.93	Brown. Put with female No. 6 in a breeding jar to mate.
5	Bangued, Abra	Sept. 20, 1937	M	3.52	2.04	0.75	0.65	0.45	0.52	1.73	1.44	1.25	0.87	Green. Mated with female No. 7.
6	Candon, Ilocos Sur	Sept. 22, 1937	M	3.62	2.05	0.75	0.68	0.47	0.51	1.77	1.47	1.33	0.92	Brown. Mated with female No. 8.
Totals				21.12	12.19	4.47	4.01	2.76	3.02					
Average ratios										1.73	1.48	1.33	0.91	

for the fact that the greater part of Luzon had not been infested. Records also show that the preceding outbreak (the 1919 outbreak) likewise started in Cotabato, Mindanao (Merino, 1919). Available evidence, therefore, tends to indicate that the main breeding ground or outbreak center of the Oriental Migratory Locust is found somewhere in the grassland areas of Cotabato—most likely in Central and Southern Cotabato, where the soil is generally sandy and where the climate is characterized by prolonged dryness. The known outbreak centers of other species of migratory locusts in other countries are known to possess similar characteristics. Loose or thin swarms, like that in Cebu, were likewise observed in other provinces such as Mindoro, Occidental Negros, Cotabato, Batangas, and Tarlac, and on the basis of these widely separated sporadic loose swarms, the writer ventured the statement that these might be indications or tell-tale signs of a forthcoming outbreak. And truly enough, the 1932 outbreak, which appeared to have started in Cotabato, came soon thereafter.

The small widely scattered infestations reported in 1918 (Merino) from Bukidnon, Nueva Ecija, Pangasinan, Davao, Sorsogon, and Cotabato, that is before the 1919 outbreak, appeared to have been like those reported in 1931, that is, they were thin swarms consisting of heterogenous individual insects belonging to the phase *transiens*, judging from specimens collected under the old Bureau of Agriculture. The occurrence of such sporadic slight infestations of the phase *transiens* appears to be a practical basis for predicting the appearance of an outbreak and as a guide as to when extensive scouting work may be started with the object of controlling swarms of the phase *transiens* in order to prevent an outbreak. Such infestations were easily stamped out by general campaigners under Locust Act No. 2472, with the exception of those in Cotabato, where the sparsity of population and lack of transportation facilities militated against effective locust control work. In 1919, Cotabato and Bukidnon remained infested and swarms coming from these provinces, especially from the former, infested other provinces in Mindanao and the Visayas. In 1922, migratory swarms had infested Luzon, as well as Mindanao and the Visayas.

That Cotabato is the most probable chief breeding or outbreak center of the Oriental Migratory Locust has been known for a long time by inhabitants in Mindanao and this is supported by records of the movements of swarms of the old Bureau of Agriculture and its successor, the Bureau of Plant Industry.

The outbreak area in which swarms breed that later will invade large areas (invasion areas) is not necessarily a large one. Thus the known outbreak area of the African Migratory Locust (*Locusta migratoria migratorioides* Reiche and Fairmaire) consists of only about 7,200 square miles (1936), yet from this area there arose and gradually spread the swarms which overran territories in Africa comprising, at the lowest computation, from 8 to 10 million square miles. Based on this ratio, an outbreak area or areas of about 92 square miles is sufficient to give rise to swarms capable of overrunning the Philippines with a total area of about 115,000 square miles. Cotabato has an area of over 9,000 square miles, so that there is no doubt that Cotabato has enough space for the breeding of locusts to such amounts as may be sufficient to overrun the entire Philippines.

It may be pointed out here that there is also the possibility of swarms flying into the Philippines from Borneo by way of the Sulu Archipelago or Celebes and Cotabato in the same way that swarms from Northern Luzon invaded Formosa, as has been reported by certain Japanese investigators (Uichanco, 1936). Borneo is a large island, relatively speaking, and it is one of the other places known where the Oriental Migratory Locust exists. Besides the fact that specimens of the solitary phase have been collected from Borneo (Uvarov, 1936), it is interesting to note from Doctor Uvarov's report that there were invasions in Borneo before outbreaks occurred in the Philippines. Thus they had an invasion in Borneo in 1918, that is before the 1919 outbreak in the Philippines. Again they had an invasion in 1931, before we had the last outbreak which started in 1932. Borneo is a large, sparsely populated island and since there is no coöperative work between the Philippines and Borneo for locust scouting and control, any swarms developing in Borneo and later invading the Philippines first through Sulu or Cotabato via Celebes [1] may easily escape notice. Borneo has an area of about 290,000 square miles, about two and a half times that of the Philippines, and with a very small population of only about 2,000,000, and as has already been pointed out the breeding or outbreak area of the Migratory Locust need not be large.

[1] It may be of interest to note in this connection that in the old Bureau of Agriculture's compilation of locust infestations there was a notation made that in 1912 dense locust swarms from Celebes and Moluccas alighted in Agusan, Mindanao.

DESCRIPTION AND DISTRIBUTION OF THE SOLITARY PHASE

Since 1932, specimens like those from Cebu, have been collected from other provinces. During August and September, 1935, several were collected from the Bureau of Plant Industry grounds in Manila, which was quite far from migratory swarm infestations then occurring in Masbate and Southern Luzon (Tayabas, Albay, Camarines Sur, and other Bicol provinces). During 1936, specimens were collected not only from Manila, but also farther north in Pampanga, Nueva Vizcaya, Isabela, and Pangasinan. During 1937, specimens were also collected from Abra and Ilocos Sur, which are still much farther north. The majority of the specimens collected are in the main green on the vertex, genae, prothorax and meso and meta-pleura, including the hind femora (plate 2, figs. 1 and 2). Others are brown (plate 3, figs. 1 and 2) and in some specimens the pronotum and vertex are dark. The pronotal keel, which distinguishes the solitary phase from the migratory phase whose pronotum is depressed or saddle-shaped, is especially pronounced in the brown specimens, that is distinctly arched, whereas in most of the green specimens it is mostly straight. Besides the keeled pronota in both sexes, solitary locust specimens are further distinguished from migratory individuals by the fact that the males are conspicuously smaller than the females. Locusts of the solitary phase, especially hoppers, were observed to have a strong tendency to resemble the color of their surroundings.

Following the classification of Uvarov and Zolotarevsky (1929) who stated, among other things, that the term *solitaria* is to be *applied to the extreme forms, the solitary individuals present in a locality, where swarms do not exist or have not existed, within at least one preceding generation,* the writer was justified in classifying the specimens collected from the aforementioned provinces as belonging to the phase *solitaria* of our Oriental species (*Locusta migratoria manilensis* Meyen), as aside from the identification by Doctor Uvarov of similar specimens from Cebu, it was definitely known that *no migratory swarm existed or had existed in the localities concerned prior to the collection of specimens.* This is particularly true in the case of those collected from Abra and Ilocos Sur, which were remote from migratory swarm infestations that were then found in Masbate and Southern Luzon. Moreover, these solitary forms are apparently well distributed there and are locally known as

"paddagan" and are even caught for food during the rice harvest season, that is during November to January. Specimens have also been collected in Cotabato, where migratory swarms have not existed for over two years, so far as extensive scouting work by fieldmen of the Bureau of Plant Industry shows. Latest observations indicate that these solitary locusts are quite common in many cultivated fields in many places during the rainy season (June to November) but are quite scarce, if at all found, during the height of the dry season (February to May).

Although the criterion of Uvarov and Zolotarevsky and the identification made by the former from specimens sent him appeared to be sufficient reason for classifying the solitary locusts collected from different places as belonging to the phase *solitaria* of the Oriental Migratory Locust, it was deemed necessary to breed some of these and also to take measurements of these and other specimens as were available as a basis for further work. The detailed results of the breeding work with these and other specimens collected will be presented in another paper. But it may be stated here in advance that in the breeding work individual locusts possessing *transiens* characters were produced from the solitary locust specimens collected from different places. For one thing, most of the hoppers in the mass cultures possessed the migratory colors—black and orange yellow or brick color. On the other hand, when the hoppers were reared separately in wire cages and breeding jars, they were mostly green. Others were grayish brown and still others had shades of these colors, depending on the cages used. They had a tendency to resemble their surroundings and retain the solitary characteristics of their parents. It may also be stated here that adult locusts reared from hoppers that hatched from eggs laid by migratory swarms showed solitary phase characters when reared separately in cages and breeding jars. These results prove definitely that the solitary locusts found in cultivated fields and grasslands and specimens of which appear in local collections as *Locusta australis* Saussure really represent the solitary phase of the Oriental Migratory Locust. Such locusts should not be confused with the common locust or grasshopper, *Gastrimargus marmoratus* (plate 5, fig. 1) which is somewhat smaller, with a prominent pinkish brown band on each side of the prothorax, basal or proximal half of the outer wings markedly ornamented with grayish spots and bands and whose tibiae are mostly pinkish red in color. The latter insect is a slower

flyer, the flights short and directed upwards and makes a peculiar noise in flight.[2]

Table 2 shows the measurements of specimens collected from different places, which were bred in the Entomology Laboratory, Manila, while table 3 gives the measurements of other solitary locust specimens, three females having been collected from Enrile, Cagayan and the rest from Cotabato, where swarms of the phase *transiens* or of the phase *migratoria* have not been found since April, 1938. The only small swarm found so far in Cotabato since that time was that of another species (*Acridium cognatum?*). A comparison of the average ratios of the measurements in table 2 with those of Uvarov shows that the specimens are wholly *solitaria* in character. The ratios show that compared with those of the phases *transiens* and *gregaria* the insects of the phase *solitaria* have relatively shorter wings, longer femora and longer and higher pronota but such pronota are thinner. The average ratios shown in table 3 likewise show that the female solitary locusts collected from Cotabato and Cagayan are wholly *solitaria* in character. In the case of the males which were all collected from Cotabato, most of them are certainly *solitaria* in character. However, the three males (4, 5, and 6) collected there recently, that is May 15, 1940, appear to show more *transiens* characters in their M/C ratios. Whether this is an indication of a possible trend in development in Cotabato toward the phase *transiens*, leading eventually to another outbreak, the extensive locust scouting work being conducted in that province should show. It may be stated in this connection that, Central and Southern Cotabato having been opened up to colonization, many of the grassland areas are being put into cultivation. Whether this and the conversion of more extensive grasslands to pasture and the wider burning of the grass in such lands, as a result of the ever-increasing population in those regions, will have any effect at all toward minimizing or entirely preventing the development of migratory swarms, so that no invasion of other provinces takes place, remains to be seen. If this turns out to be the case, the question as to whether or not other provinces, like Davao, Negros, Mindoro, Isabela, Mountain Province, Cagayan, etc. are capable of breeding migratory swarms, as other investigators believe, as Goseco (1933) for instance, may be solved.

[2] Other species that may be mistaken for the solitary phase of the Migratory Locust are *Valanga nigricornis* and *Acridium cognatum? -Melicodes tenebrosa?* (see plate 5).

The relatively shorter wings and longer femora seem to fit the relatively inactive life of the individual locusts belonging to the solitary phase—that is, they seldom fly and do not do so for considerable distances, unlike those of the migratory phase which even cross large bodies of sea. It is logical to deduce, therefore, that other criteria being considered, the lower the E/F ratio a solitary locust specimen has, the shorter the wings in relation to the femur and the more is it truly *solitaria* in character. And of all ratios, the E/F ratio is the most reliable as a basis of comparison for the different phases as the tegmina or outer wings and the femora can be more accurately measured than the length, height and constriction of the pronotum and width of head. Moreover, according to Johnston (1936), this ratio is considered the most widely useful in application, which may be due to the fact that organs more intimately connected

TABLE 3.—*Solitary locusts collected from Cotabato since April, 1938, when no more migratory swarms were found and since which date the province has been declared under observation. Three female specimens from Enrile, Cagayan are included.*

Number	Sex	E	F	P	H	M	C	E/F	P/C	H/C	M/C
1	F	4.66	2.65	1.03	0.95	0.70	0.73	1.79	1.41	1.30	0.96
2	F	4.61	2.69	0.98	0.92	0.64	0.69	1.71	1.42	1.33	0.92
3	F	4.74	2.88	1.12	0.96	0.70	0.74	1.64	1.51	1.29	0.94
4	F	4.95	2.73	1.02	0.95	0.71	0.74	1.81	1.38	1.28	0.96
5	F	4.82	2.65	0.96	0.94	0.70	0.73	1.82	1.32	1.29	0.96
6	F	4.80	2.66	1.05	0.90	0.66	0.70	1.80	1.46	1.25	0.92
7	F	4.55	2.72	0.92	0.86	0.65	0.70	1.67	1.31	1.23	0.93
8	F	4.60	2.62	1.05	0.92	0.64	0.69	1.60	1.52	1.33	0.93
9	F	4.70	2.65	1.05	0.93	0.66	0.70	1.77	1.50	1.33	0.90
10	F	4.34	2.36	0.97	0.83	0.61	0.70	1.84	1.39	1.12	0.89
11	F	4.95	2.94	1.12	1.01	0.71	0.78	1.68	1.43	1.29	0.91
Totals		51.72	29.55	11.27	10.17	7.38	7.90				
Average ratios								1.75	1.42	1.28	0.93
1	M	3.39	1.92	0.74	0.65	0.45	0.50	1.76	1.48	1.30	0.90
2	M	3.34	1.95	0.78	0.64	0.47	0.52	1.71	1.50	1.23	0.90
3	M	3.48	2.00	0.70	0.65	0.47	0.51	1.74	1.37	1.27	0.92
4	N	3.71	2.09	0.80	0.69	0.47	0.54	1.77	1.48	1.27	0.87
5	M	3.75	2.06	0.82	0.69	0.48	0.55	1.82	1.49	1.25	0.87
6	M	3.31	1.92	0.75	0.63	0.42	0.49	1.72	1.53	1.31	0.86
Totals		20.98	11.94	4.59	3.95	2.76	3.11				
Average ratios								1.75	1.47	1.27	0.88

NOTE.—Females Nos. 1, 2, and 3 were collected from Buayan, Cotabato, May, 1938. Females 7, 8, 9, and 10 were also collected from Buayan, May 29 to 31, 1939. Nos 4, 5, and 6 were collected from Enrile, Cagayan, September 14, 1938, while No. 11 was collected from Koronadal, Cotabato, May 15, 1940.

Males No. 1 was collected from Isulan, Cotabato, May, 1938; 2 and 3 from Buayan, Cotabato, May 29–31, 1939; and 4, 5, and 6 from Koronadal, Cotabato, May 15, 1940. (Most of the Cotabato specimens were collected by T. Villalon and the Cagayan specimens by A. Valdivia, of the Plant Pest and Disease Control Division).

with movement are the first to be affected by change of habits and are probably least affected by shrinkage as a result of the drying of the specimens. That a lower E/F ratio, other characters being considered, is indicative of a more truly phase *solitaria* character seems to be borne out by the solitary locust specimens, which were collected from places more or less remote from migratory swarm infestations, especially by those given in table 2, all the E/F ratios of which are below 1.80. Most of those given in table 3 likewise have E/F ratios below 1.80, and in both tables some specimens have E/F ratios falling below 1.70. It may, therefore, be suggested that, other characters being considered, such specimens with E/F ratios falling below 1.80 may be classified as belonging to the phase *solitaria*. Those with ratios falling below 1.70 probably represent the extreme solitary forms of the Oriental Migratory Locust.

TABLE 4.—*Average ratios for the different phases of the Oriental Migratory Locust.*

Phases	E/F	P/C	H/C	M/C
Phase *solitaria:*				
Male	1.73	1.48	1.33	0.91
Female	1.74	1.44	1.38	0.92
Phase *transiens:*				
Male	1.83	1.25	1.19	0.86
Female	1.91	1.25	1.20	0.88
Phase *gregaria:*				
Male	2.12	1.10	1.05	0.81
Female	2.18	1.10	1.04	0.88

In accordance with the foregoing suggestion, the average of the average ratios for the males in tables 1, 2, and 3, which are E/F 1.74; P/C 1.47; H/C 1.32; M/C 0.90; and the average of the average ratios for the females in tables 2 and 3, which are 1.74; 1.43; 1.31 and 0.92 (the females in table 1 being more *transiens* in E/F character, the average ratios of their measurements are not included), may be used (instead of Uvarov's average ratios—for male E/F 1.87; P/C 1.33; H/C 1.25; M/C 0.91 and for female 1.92; 1.53; 1.31 and 0.92, respectively—which were calculated from measurements of only one male and one female from China, which specimens appear to be more *solitaria* than *transiens* in their E/F ratios) in ascertaining whether any given specimen belongs to the phase *solitaria* as distinct from *transiens* or *gregaria*. But mainly because the specimens in table 2 have been bred, collected from places more or less remote from migratory swarm infestations and all of

them appear to be distinctly solitary in E/F ratios, the average ratios of the measurements of these, which are, for male E/F 1.73; P/C 1.48; H/C 1.33; M/C 0.91 and for female 1.74; 1.44; 1.38 and 0.92, respectively, may logically better be used instead of the average of the average ratios as suggested. At any rate the figures differ but slightly and either set of average ratios may be used. But, because of the reasons set forth, the ratios from the bred specimens have been used in table 4, which gives all the average ratios for all the phases, thus facilitating the placement of any given specimen. The figures for the phase *transiens* in said table are the average ratios of Uvarov for all such specimens, including those from Los Baños, and those for *gregaria* are the average of the average ratios of Uvarov (1936) and of Uichanco and Gines (1937), with the exception of the ratios M/C (0.81 and 0.83), which are solely of Uvarov, as the latter authors do not give any corresponding averages in their table 8, comparing their average ratios with the corresponding ratios of Uvarov.

DEVELOPMENT OF MIGRATORY SWARMS

From the foregoing observations, it is apparent that the solitary forms of the Oriental Migratory Locust are widely distributed in the Philippines. In places, these at times produce thin swarms of the phase *transiens*, which seldom, if ever, succeed in developing into the migratory stage both as to morphology and habits. This is especially true in provinces which are more or less well populated and where most of the land has been brought into cultivation. The changes in environmental conditions through cultivation, grazing, etc. perhaps render the development of *transiens* swarms abortive. Likewise, frequent burning of the uncultivated grasslands perhaps also contribute to this end, to say nothing of the rôle of natural enemies and the fact that in many places the insects are caught for food. Any factor that contributes to the lessening of the density of a swarm will tend to speed up the change in development into the solitary phase. Thus, according to Uvarov (1928) birds are important in this respect, not because they eat many locusts but because they scatter the swarms and thus speed up the process of transformation into solitary phase. Birds are of great help in hastening the disappearance of small scattered migratory swarms, such as those left after extensive general campaigns. Uvarov (1928) also stated that the regularity of the process of transformation into the swarming or migratory phase "may be

sometimes destroyed by the interference of man, who scatters the bands of hoppers and the swarms when they are just formed, and this stops or at least retards the process. In some cases such interference is regular, consisting in artificial changes of the ecological conditions in the permanent breeding grounds so that even the initial increase in numbers of the insects becomes difficult. This is what happened with *Locusta migratoria*, many breeding grounds of which have ceased to function as a result of the interference of man; the same is probably the cause of the disappearance of the swarming phase of the Rocky Mountain Locust, though it cannot be stated definitely."

It is apparently in the vast uninhabited interior places in Mindanao, particularly in Cotabato, where the Oriental Migratory Locust succeeds in developing into dense migratory swarms thus giving rise to recurrent outbreaks. Hence, it is in Cotabato where most of the locust scouting is being and will be conducted in order to locate initial swarms (phase *transiens*) and kill these by all methods known, such as by poisoned baits and dusting with arsenical and derris powders,[3] before they have a chance to develop into migratory swarms. It is also there where observations with the object of delimiting the outbreak areas of the migratory locust should be made. Once such areas are delimited, a study of the various local factors that influence outbreaks may then be conducted to the end that definite steps may be taken whereby conditions in the outbreak areas may be modified, thus at least curtailing, if not entirely preventing, the development of migratory swarms.

Since June, 1939, when Masbate, the Bicol provinces and Tayabas were placed under observation after the last swarms in those provinces were controlled, extensive locust scouting work was continued there and in Mindanao, particularly Cotabato. Cotabato was placed under observation in April, 1938. It is interesting to note that since then no swarm of the phase *transiens* or phase *gregaria* has been found. However, locust specimens, which, as has already been shown, belong to the phase *solitaria*, have been collected there, as well as in certain other places. That locust swarms have not been encountered in Cotabato in spite of the extensive scouting work there seems to

[3] Laboratory and field tests have been carried on with [illegible] dust with a rotenone content of [illegible] per cent is deadly to locusts, the hoppers and hoppers. Derris powder may, however, be employed instead of arsenicals the extensive use of which is restricted because of the risk to stock and operators.

contradict the view that swarms, whether of the phase *transiens* or *gregaria* from which a new outbreak may arise, are found in Cotabato all the time. From this it may be deduced that a new outbreak of the Oriental Migratory Locust must necessarily start with the solitary phase.

SUMMARY

A brief review of the phase theory in connection with the biology of migratory locusts is given.

An explanation on how and why solitary locusts come together, breed and produce thin or loose swarms of the phase *transiens*, these eventually developing into migratory swarms (phase *gregaria* or *migratoria*), is also given.

The duration and intervals of locust outbreaks in the Philippines are likewise given.

Identification of specimens by Dr. B. P. Uvarov, measurements of specimens and breeding work show conclusively that the solitary locusts, formerly identified as *Locusta australis* Saussure, in reality represent the solitary phase of the Oriental Migratory Locust, *Locusta migratoria manilensis* Meyen. Specimens belonging to the solitary phase of this phase are described. These should not be confused with the common grasshopper, *Gastrimargus marmoratus*, a smaller species which is a slow flyer and with a prominent pinkish brown band on each side of the prothorax, basal half of outer wings markedly ornamented with grayish spots and bands and with pinkish red tibiae.

Measurements of such specimens as were available are given, as a basis for further work. Other characters considered, such specimens with E/F ratios falling below 1.80 may be classified as belonging to the phase *solitaria*. Specimens with E/F ratios falling below 1.70 probably represent the extreme solitary forms of the species. The average ratios from the specimens bred, as given in table 2, which are for male E/F 1.73; P/C 1.48; H/C 1.33; M/C 0.91; and for female E/F 1.74; P/C 1.44; H/C 1.38; M/C 0.92, may for the reasons set forth preferably be used (instead of those of Uvarov's ratios which were calculated from measurements of only two specimens—one male and one female) for definitely distinguishing the phase *solitaria* from the *transiens* and *gregaria* or *migratoria* (using in this connection the average ratios of Uvarov for the phase *transiens* and Uichanco and Gines' ratios for *migratoria* or more logically

the average of the average ratios of Uvarov and Uichanco and Gines) considering also, of course, other characters and criteria. To facilitate the placement of any given specimen table 4 should be referred to.

Locusts belonging to the solitary phase of the Oriental Migratory Locust are apparently well distributed in the Philippines. During the rainy season specimens may be found in cultivated fields and grasslands in many provinces during June to November, but scarce during February to May, that is during the greater part of the dry season.

Loose or thin swarms of the phase *transiens* appear here and there in cultivated and grassland areas in many provinces. Owing perhaps to changed environmental conditions through cultivation, grazing, burning in grasslands, catching of the insects by persons for food, etc., these *transiens* swarms seldom, if ever, succeed in developing into the migratory phase. The sporadic appearance of such thin swarms during periods when there are no migratory swarms have proved so far to be a reliable and practical basis for predicting the occurrence of a new outbreak and as a guide for conducting the scouting work in the permanent breeding places or outbreak areas.

As far as observations and records show, the outbreak areas of *Locusta migratoria manilensis* Meyen are found in Cotabato. Available evidence also tends to show that swarms, whether of the phase *transiens* or phase *migratoria*, do not exist in Cotabato all the time and that fresh outbreaks must necessarily start from the solitary, in accordance with the phase theory and outbreak cycles. That the latter is more likely the case may be shown theoretically, aside from the results of the extensive scouting work. Some of the solitary females bred in the Entomology Laboratory in Manila had produced more than 500 nymphs or hoppers. Allowing 300 as the average number of young that a female can produce, it has been calculated that a pair of solitary locusts may produce in the third generation, that is, in about a year's time, an enormous amount of progeny numbering 1,012,500,000. This would amount to over 42,000 cavanes and the swarm would cover roughly about two square miles. When an outbreak impends the environmental resistance is likely to be low; otherwise dense swarms will not be formed and an outbreak will not take place. The point suggested by these considerations is that there need not be a swarm to start an outbreak—that is, a relatively few solitary locusts may suffice.

The possibility of locust swarms invading the Philippines from Borneo, a large thinly populated island more than twice the area of the Philippines, in the same way that swarms from Luzon also invaded Formosa, as has been reported by certain Japanese investigators, is discussed. The existence of the solitary phase of the Oriental Migratory Locust in Borneo and the occurrence of outbreaks in Borneo shortly before outbreaks in the Philippines point to such a possibility. At least, swarms coming from Borneo may contribute to infestations, or join swarms of local origin.

Since Cotabato, judging from the records, is likely the main permanent breeding area or outbreak center of the Oriental Migratory Locust, it is accordingly there that most of the scouting and control work, with the object of preventing the development of large migratory swarms is being and will be conducted. A study of the factors that influence outbreaks may be centered in Cotabato to the end that definite steps may be taken whereby conditions in the outbreak area or areas may be modified or altered so as to curtail, if not entirely prevent, the development of migratory swarms. However, locust scouting and observations should also be made in other provinces that are more or less sparsely populated in order to secure definite data on the solitary phase, on initial or *transiens* swarms and on the behavior of these with due consideration to environmental factors.

With the opening up of Central and Southern Cotabato in particular to colonization, many of the grassland areas there are being put into cultivation. Whether this, and conversion of more grasslands to pasture and the wider burning of grasslands as a result of the ever-increasing population in those regions, will have any effect toward minimizing, or entirely preventing, the development of migratory swarms in Cotabato so that no invasions in other provinces will take place, remains to be seen.

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ILLUSTRATIONS

Plate 1

Diagram of measurements to be taken on a locust for calculating biometric ratios (Redrawn from the 1936 Proceedings of the Fourth International Locust Conference, Cairo, Egypt):

E—Length of elytron, or tegmen or outer wing
F—Length of posterior femur
P—Length of pronotum
M—Width of constriction of pronotum
H—Height of pronotum
C—Maximum width of head

Plate 2

Figs. 1 and 2. Male and female green forms of the solitary phase of the Oriental Migratory Locust, *Locusta migratoria manilensis* Meyen.

3. A female locust belonging to the migratory phase. Note the depressed or saddle-shaped form of the prothorax in contrast to that of the solitary, the pronotum of which is ridged, keeled, convex or straight. Figures enlarged.

Plate 3

Figs. 1 and 2. Male and female brown forms of the solitary phase of the Oriental Migratory Locust. Figures enlarged.

Plate 4

A map of the Philippines showing the general movement of locust swarms during the 1932-1939 outbreak—as indicated by arrows. Shaded area in Cotabato and part of Davao indicates the most probable outbreak area of the species. (Extensive campaigns were conducted in all the places visited by swarms. Arsenical dust poisons, poison baits and soap solutions were used against hoppers—along with usual mechanical methods employed in general campaigns under Locust Act No. 2472. These apparently account chiefly for the relatively short duration of the said outbreak and the fact that it had not become so widespread, swarms having reached only as far north as Laguna and Batangas).

Plate 5

Other species of locusts liable to be mistaken (in fact have been mistaken) for the solitary phase of the Oriental Migratory Locust.

Fig. 1. *Gastrimargus marmoratus* (green form), about 1x.

2. *Acridium cognatum* Stål (*Melicodes tenebrosa* Wlk.) (?), about 1x.
3. *Valanga* (*Cyrthacanthacris*) *nigricornis* Burm. (Identification verified by Dr. P. van der Goot of the Institute for Plant Diseases and Entomology, Buitenzorg, Java), about 1x.

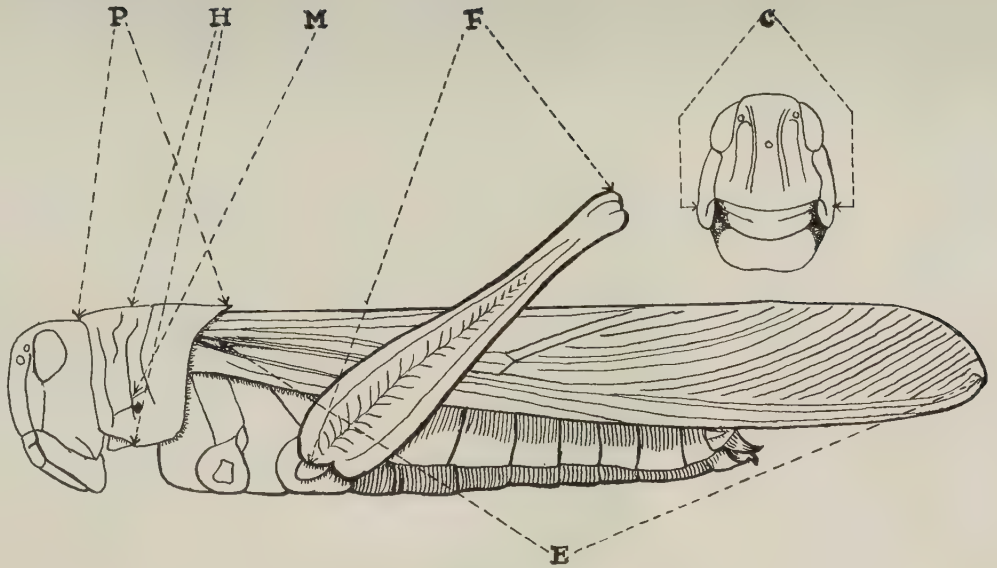
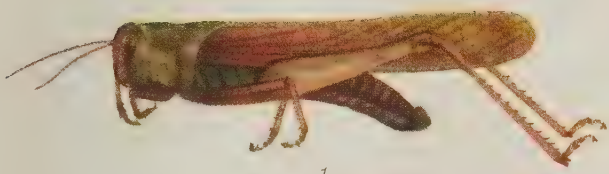


PLATE 1.



1

2

3

PLATE 2.

1

2

PLATE 3.

BATANES PROV.
BABUYAN ISLANDS
CAGAYAN
ILOCOS NORTE
ABRA
MOUNTAIN PROVINCE
ISABELA
LA UNION
ILOCOS SUR
NUEVA VIZCAYA
PANGASINAN
NUEVA ECIJA
TARLAC
ZAMBALES
PAMPANGA
BULACAN
RIZAL
BATAAN
LAGUNA
BATANGAS
LUBANG I.
MARINDUQUE
MINDORO
CATANDUANES I.
CAM. SUR
SORSOGON
SCALE OF MILES
0 50 100 150 200
ROMBLON I.
ROMBLON PROV.
BUSUANGA I.
CULION
CUYO
CUYO I.
PUNARAN I.
PALAWAN
CAPIZ
PANAY
NEGROS
SAMAR
LEYTE
DINAGAT I.
SIARGAO I.
BOHOL
MINDANAO
DAVAO
COTABATO

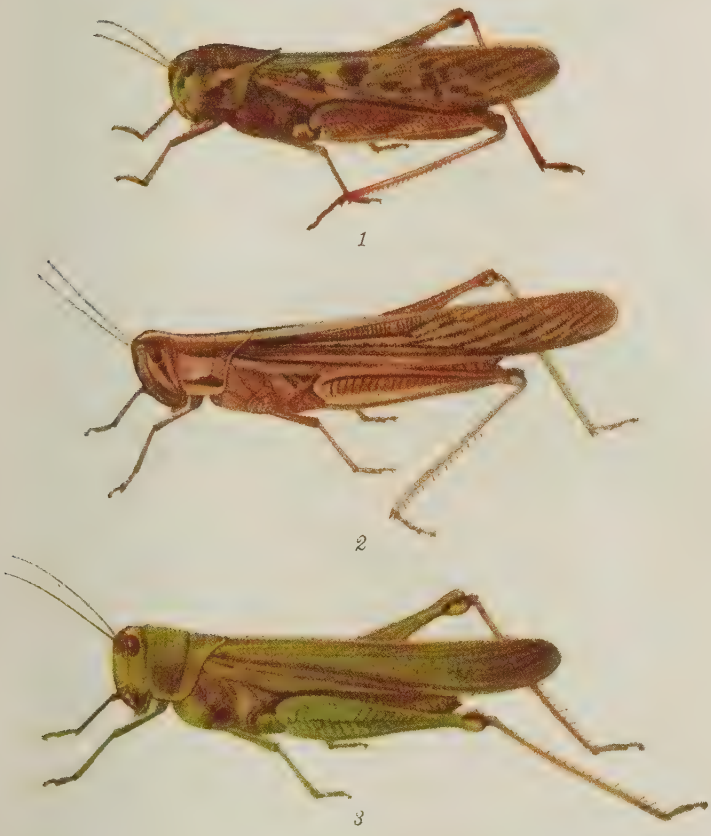


PLATE 5.

THE EFFECT OF VOLCANIC ASH EJECTED FROM MAYON VOLCANO UPON THE GROWTH OF TOBACCO[1]

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THREE PLATES AND ONE TEXT FIGURE

Mayon Volcano has erupted many times. As cited by Adams and Pratt[2] its first eruption was in the year 1616, the second and succeeding eruptions being in 1660, 1800, 1814, 1827, 1845, 1846, 1851, 1853, 1855, 1871, 1872, 1873, 1881–1882, 1885, 1885–1887, 1888, 1890, 1891, 1892, 1893, 1895, 1896, and 1897. The last was in June, 1938.

When Mayon Volcano erupted in 1897, Padre Jose Coronas stated that hot ashes fell in Tabaco, and, according to one report, 50 centimeters of ashes fell in 24 hours in that town, and in Tiwi, during the same interval, 15 to 20 centimeters. Another report states that 15 centimeters of ashes fell in Tabaco. Small stones, the size of pigeon eggs, were reported to have fallen in Ligao and in Camalig. In Albay and Daraga the fall of ashes was about 1,002 millimeters and in Legaspi less. In Virac, Catanduanes Island, 5 to 6 centimeters of ashes and the conflicting statements as to their depth are explained by Coronas as being due to the variation and action of the wind.

In June, 1938, when Mayon Volcano erupted, 2 to 5 millimeters thick of ashes fell at Daraga, Camalig, Guinobatan, and Ligao. At barrio Midela about 3.5 cm. thick of ashes were found on an empty river bed. No appreciable amount of volcanic ash fell on the nearby towns on the north and east sides of Mayon Volcano, but on the western part particularly in the municipalities of Camalig, Guinobatan, and Ligao, the leaves of abaca and banana plants were scorched badly as a result of the accumulation of fine volcanic ash on the leaves of these plants (text fig. 1). What is the subsequent effect of the volcanic ash deposited on the soil upon the later growth of the plants? No satisfactory answer could be given to the question at that time except by inference from the results of the analyses of the Mayon volcanic dust collected by Sherman(10). She found .091 per cent nitrogen, 0.266 per cent phosphorus, 1.605 per cent potash and 0.023 per cent acidity. These substances which are

[1] Received for publication September 9, 1940.

[2] Cited by George I. Adams and Wallace E. Pratt. Geological reconnoissance of southwestern Luzon. Philip. Journ. Sci. 6 (1911) No. 6.

found in the volcanic ash, when added to the soil in soluble form especially when the soil is deficient in any one of them, are beneficial to the growth of the plants. But are those elements reported by Sherman the only substances present in the ejecta of Mayon Volcano? According to Cox's(1) report on the finer ejecta of Taal Volcano, a number of different substances were found as can be seen in table 1.

TABLE 1.—*Analyses of the finer ejecta from Taal Volcano and of volcanic tuff.*

Constituent	Finest ash from upper southern slope of Taal		Ejecta from area where mud was 1 cm. deep		Tuff from Guadalupe			
NOT READILY SOLUBLE IN WATER	I[a]	II[c]	III[a]	IV[b]	V	VI	VII	VIII
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Silica (SiO_2)	45.76	50.79	44.63	50.94	56.84	56.55	59.27	57.26
Alumina (Al_2O_3)	14.57	16.17	13.33	15.22	18.46[e]	22.34[e]	17.06	16.95
Ferric oxide (Fe_2O_3)	2.89	3.20	3.24	3.70	0.75	1.87	2.16	-------
Ferrous oxide (FeO)	5.20	5.77	5.04	5.76	2.51	-------	2.61	7.55
Lime (CaO)	6.94	7.70	6.25	7.13	4.78	4.74	3.37	3.56
Magnesia (MgO)	2.59	2.87	2.70	3.08	1.59	2.36	1.52	1.10
Soda (Na_2O)	None	-------	None	-------	4.12	2.38	.49	1.64
Potash (K_2O)	None	-------	None	-------	2.72	2.84	3.63	1.86
Loss on ignition	1.18	1.31	1.19	1.36	6.95	4.86	6.42	7.65
Water (H_2O) (below 105–110°)	5.03	None	6.35	None	1.76	2.51	1.34	1.43
Titanic oxide (TiO_2)	1.20	1.33	1.14	1.30	(e)	(e)	0.83	0.91
Manganese oxide (Mn_3O_4)	Trace	Trace	Trace	Trace	Trace	-------	Trace	0.23
Sulphuric anhydride (SO_3)	9.49	10.53	10.11	11.54	-------	-------	-------	-------
Free sulphur (S)	0.45	0.50	0.37	0.42	-------	-------	-------	-------
Phosphoric anhydride (P_2O_5)	0.05	0.06	0.03	0.03	-------	-------	-------	-------
READILY SOLUBLE IN WATER[f]								
Silica (SiO_2)	0.82	-------	0.95	-------	-------	-------	-------	-------
Iron and aluminum oxides (R_2O_3)	0.01	-------	Trace	-------	-------	-------	-------	-------
Lime (CaO)	0.16	-------	0.32	-------	-------	-------	-------	-------
Magnesia (MgO)	None	-------	None	-------	-------	-------	-------	-------
Soda (Na_2O)	1.51	-------	2.03	-------	-------	-------	-------	-------
Potash (K_2O)	1.34	-------	1.25	-------	-------	-------	-------	-------
Manganese oxide (Mn_3O_4)	Trace	-------	Trace	-------	-------	-------	-------	-------
Sulphuric anhydride (SO_3)	0.30	-------	0.60	-------	-------	-------	-------	-------
Phosphoric anhydride (P_2O_5)	None	-------	None	-------	-------	-------	-------	-------
Chlorine (Cl)	0.74	-------	0.95	-------	-------	-------	-------	-------
Total	100.23	100.23	100.48	100.48	100.48	100.44	100.70	100.14

[a] Analyzed mostly by Dr. T. Dar Juan.

[b] These numbers are approximately comparable to Columns V to VIII, although it is quite probable that in time the [illegible] would be [illegible] or hydrolysed and give a closer relationship to the tuff which is found in various places in the Island of Luzon than that shown by these analyses.

[c] Includes titanic oxide (TiO_2).

[d] Actual loss on ignition—(moisture + sulphuric anhydride + ½ sulphur).

[e] Included in alumina (Al_2O_3).

[f] Three months after collection.

TEXT FIGURE 1. A portion of the map of the Province of Albay showing the extent of destruction to agronomical crops two weeks after the eruption of Mayon Volcano on June 5, 1938.

It can be seen in table 1 that at least twelve inorganic substances were reported present in the fine ejecta of Taal Volcano, among which silica was highest (44.63 to 59.27 per cent), and alumina was second (13.33 to 22.34 per cent). Nitrogen was absent. Very likely the same kind of substances found in the fine ejecta of Taal Volcano may also be present in the ashes ejected by Mayon Volcano. And, if this is the case, the effect of the aluminum in the volcanic ash upon the plant is worthy of study because, according to Ruprecht(9), aluminum sulphate solution has a very toxic action on clover seedlings when present in a medium greater than 40 parts per 1,000,000. Similarly, Miyake(7) showed that aluminum chloride is toxic to rice seedlings in concentrations greater than N/7,500. Further, Mirasol(6) and McLean and Gilbert(4) reported the high toxic effect of aluminum compounds on plants like barley and lettuce when present in an appreciable quantity in the culture medium. But later in 1928, McLean and Gilbert(5) also observed that very low concentrations of aluminum (3 to 13 ppm) were stimulatory to plants. These findings make the study important because of the absence of a quantitative determination of the effect of the volcanic dust upon the growth of the tobacco plant [3] and because of the incompleteness [4] of the analyses of the composition of the volcanic dust as reported by Sherman. This needed information prompted the studies conducted in the laboratory of the Tobacco Research Section, Bureau of Plant Industry during the years 1938 and 1939.

MATERIALS AND METHOD

Collection of volcanic ash, ordinary garden soil and their treatments.—On June 20, 1938, volcanic ash was gathered from the surface of galvanized iron roofs of houses in the different barrios of the municipalities of Guinobatan and Ligao, Albay. Sufficient samples were secured and placed in jute bags for shipment to the Central Office, Manila, for laboratory study. Immediately after receipt of the material in Manila, enough sample for chemical analysis was placed into a bottle, stoppered,

[3] Tobacco plant was used as subject of study because it is one of the best plant indicators for soil conditions.

[4] Dr. N. L. Galvez of the College of Agriculture gathered some of the fine ejecta of Mayon Volcano at the same time with the author and reported the chemical and physical examinations of the composition of his samples in the Philippine Agriculturist 27 (1939) 765–774.

and sent to the Bureau of Science to be analyzed for total silica, alumina, ferric oxide, ferrous oxide, lime, magnesia, soda, potash, nitrogen, phosphorus, manganese, sulphuric anhydride and free sulphur and for pH value determination.

Sufficient ordinary garden soil for experimentation was also gathered at the Central Experiment Station field, Manila, and placed in the greenhouse to dry. The soil was then thoroughly mixed. A representative sample of the soil was also taken and placed into a bottle, stoppered, and sent together with the volcanic ash to the Bureau of Science for total nitrogen, phosphorus, potassium and pH value determination.

Preparation and conduction of pot cultures.—Three sets of pot cultures designated as test A, test B and test C were conducted. Tests A and B were performed at the same time and the cultures were placed practically under the same aërial environmental conditions. Test C was conducted after the results of tests A and B were obtained.

Test A consisted of sixteen pot cultures and was treated as follows: Two pots were filled with eight kilograms of ordinary air-dry garden soil previously prepared and into another two pots, eight kilograms of air-dry volcanic ash were placed. The remaining six pairs of pots contained also eight kilograms of a mixture of garden soil and volcanic ash of varying percentages, viz., five, ten, twenty, thirty, forty, and fifty. The five per cent mixture (garden soil and volcanic ash) was prepared by replacing 400 grams of garden soil with an equivalent weight of volcanic ash. The two substances (400 gms. volcanic ash and 7,600 gms. garden soil) were mixed and the combination was designated as a five per cent mixture. The other percentages were prepared similarly and accordingly. The soil medium in each of the sixteen pots was moistened with water to its optimum moisture-holding capacity. A good-sized tobacco seedling was planted in each pot. The pot cultures were then weighed and placed in the greenhouse. Whenever the plants needed water, the culture pots were reweighed and the lost weights were replaced by pouring water into the pots.

Test B was a repetition of test A except for the method of watering the plants. The pot cultures (test B) were placed in shallow containers with water so that when the pot cultures were dipped into the water, a depth of an inch of water outside each pot was observed. The depth of water in the water container was regulated by a hole bored through one of its sides at a height of one inch from the bottom. The earthen pots

being porous, the plants were supplied with water by capillary attraction through the bottom and wall of the pots. Water was added into the water receptacle as frequently as was necessary (plate 2). Test B was placed side by side with test A in the greenhouse. At the termination of the test the moisture content of the soil contained in the different pot cultures was ascertained, and the results expressed on the dry basis.

As containers in test C, six earthen pots having the same top area and depth (16.5 cm. deep and 16 cm. in diameter) were selected. All the pots were filled with equal amounts of ordinary garden soil. The first two pots were planted to tobacco seedlings and served as control. On the surface of the soil contained in the other two pots, volcanic ash as thick as two and one-half centimeters (750 gms.) was placed. The medium was moistened and later planted to tobacco. On the surface of the soil in the remaining two pots two and one-half centimeters of volcanic ash was also placed, but the volcanic ash was thoroughly mixed with the garden soil. The medium was then also moistened with water and planted to tobacco. All the six pot cultures were placed outside the greenhouse, and whenever the plants needed water all the cultures were watered uniformly.

RESULTS

The results of the experiment are presented in tabulated form and grouped into two, namely, the chemical composition of the volcanic ash and the ordinary garden soil on one hand, and plant response on the other.

Chemical composition of medium.—Table 2 shows the chemical composition of the fine ejecta of Mayon Volcano. The results of the analyses of Dr. N. L. Galvez of the College of Agriculture, University of the Philippines were tabulated with the results of analyses of the Bureau of Science, Manila, for comparison. Also the amount of nitrogen, phosphorus and potassium present in the ordinary garden soil was given.

Table 3 shows the computed amount of nitrogen, phosphorus, and potassium present in every pot culture. These figures were obtained from the results of the analyses presented in table 2.

Plant response.—The results of the three test cultures conducted are presented in tables 4, 5, and 6. Table 4 shows the effect of varying percentages of volcanic ash upon the growth of tobacco plants grown in pots placed under greenhouse conditions during the months of September and October, 1938. Another

set of data gathered during the months of February and March, 1939 is presented in table 5. Table 6 shows the results of test C conducted during the months of November and December, 1939.

DISCUSSION OF RESULTS

The ash ejected by Mayon Volcano (table 2) contained the major essential food elements necessary for normal growth of green plants. These are potassium, calcium, magnesium, phosphorus, sulphur, and nitrogen. Also, some of the trace elements needed for plant growth such as iron and manganese were present. The constituent of the volcanic ash that was present in the highest amount was SiO_2, being 56.65 per cent. This was followed in the descending order by Al_2O_3, CaO, Fe_2O_3, FeO, MgO, Na_2O, K_2O, P_2O_5, SO$_3$, MnO, N, and S. The substances found were practically the same in kind and quantity as those reported by Galvez (table 2) except that in his report nitrogen was absent[5].

TABLE 2.—*Analyses of the fine ejecta of Mayon and Taal volcanoes and ordinary garden soil.*

Constituents	Mayon Volcano		Taal volcano ash [a]	Ordinary garden soil [d]
	(a)	(b)		
	Per cent	*Per cent*	*Per cent*	*Per cent*
SiO_2	56.65	56.36	50.79	
FeO	3.31		5.77	
Fe_2O_3	3.66	[e] 8.33	3.20	
Al_2O_3	20.30	19.37	16.17	
CaO	7.18	8.50	7.70	
MgO	3.07	1.13	2.87	
SO_3	.14	.40	10.53	
S	Nil		.50	
P_2O_5	.44	.56	.06	.24
K_2O	.50	1.16		.79
Na_2O	1.24	2.12		
N	.01			.10
MnO	.13			
Mn_3O_4		.44	Trace	

[a] Volcanic ash, pH, 5.2; [d] Garden soil, pH 6.30.

[a] Analyzed by Messrs. R. R. Oliver and J. Roco (Aug. 15, 1938) Bureau of Science, Manila.

[b] Reported by Dr. N. L. Galvez (1939), College of Agriculture.

[c] Analyzed by Cox (1911). Finest ash from upper southern slope of Taal.

[d] Analyzed by Mr. R. T. Marfori for P_2O_5, K_2O, and N only (Aug. 15, 1938).

[e] Includes FeO.

[5] The samples used in the study contained 0.01 per cent nitrogen. If nitrogen is really wanting in volcanic ash, its presence in the sample is attributed to be due to some organic matter collected together with the volcanic ash.

Volcanic ash is not toxic to tobacco plant.—Tobacco being a leaf crop, the height of stem was not considered a good criterion for the study of the effect of the volcanic ash upon the growth of the tobacco plant for obvious reasons. The total leaf area (leaf product) and dry weight of leaves were used instead. The results of test A (tables 4 and 5) show that the control plants grown in garden soil only had the biggest leaf product and heaviest dry weight of leaves. The plants grown in volcanic ash were the smallest and those grown in soil with volcanic ash of varying percentages were intermediate. It was also observed that the higher the percentage of volcanic ash in the culture medium, the poorer was the growth of the plant and also the lighter the total air-dry weight of the leaves of one plant. No sign of aluminum toxicity was observed although volcanic ash analyses contained 20.30 per cent Al_2O_3. It is very apparent that this metal was not rendered soluble or the toxic effect of active aluminum (if present) in the culture medium upon the tobacco plant was inhibited or prevented by the presence of sufficient amount of CaO and P_2O_5 in the soil medium. For, according to Hartwell and Pember (2, 3) the practical advantage of phosphating and liming soil lies in the precipitation of active Al. Volcanic ash contained 7.18 and 0.44 per cent CaO and P_2O_5, respectively.

TABLE 3.—*Computed amount of N, P_2O_5 and K_2O in every pot culture of tests A and B based on results of analyses as reported in table 2.*

Culture media per cent mixture	Nitrogen (N)			Phosphorus (P_2O_5)			Potassium (K_2O)		
	Garden soil	Volcanic ash	Total	Garden soil	Volcanic ash	Total	Garden soil	Volcanic ash	Total
	gm.	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
[a]	8.00	-------	8.00	19.20	-------	19.20	63.20	-------	63.20
5	7.60	.04	7.64	18.24	1.76	20.00	60.04	2.00	62.04
10	7.20	.08	7.28	17.28	3.52	20.80	56.88	4.00	60.88
20	6.40	.16	6.56	15.36	7.02	22.38	50.56	8.00	58.56
30	5.60	.24	5.84	13.44	10.54	23.98	44.24	12.00	56.24
40	4.80	.32	5.12	11.52	14.08	25.60	37.92	16.00	53.92
50	4.00	.40	4.40	9.60	17.60	27.20	31.60	20.00	51.60
[b]	-------	.80	.80	-------	35.16	35.16	-------	40.00	40.00

[a] Garden soil, control. [b] Volcanic ash.

The downward trend of growth of the volcanic ash-treated plants showing a direct relation to an increase in the percentage of volcanic ash in the soil mixture (plates 1 and 3) was attributed to be mainly due to the decreasing effect of the total

TABLE 4.—*Effect of volcanic ash upon the growth of tobacco plants grown in pots under greenhouse condition (first trial).*

Culture media per cent mixture	Average height		Average total leaf product		Average dry weight of leaves		Average measurements of biggest leaf of 2 plants				Description of plant at end of culture
							Test A		Test B		
	Test A	Test B	Test A	Test B	Test A	Test B	Length	Width	Length	Width	
	cm.	*cm.*	*sq. cm.*	*sq. cm.*	*gm.*	*gm.*	*cm.*	*cm.*	*cm.*	*cm.*	
(a)	66.0	80.5	1,302.5	1,325.5	4.5	4.8	19.5	9.5	21.5	9.8	Test A. Growth, poor. Leaves, pale green. Plants slender. Test B. Growth, poor. Leaves, pale green. Plants slender.
5	60.5	90.0	1,287.9	1,472.9	4.5	5.8	19.5	9.1	22.0	10.5	Do.
10	52.5	94.0	1,157.5	1,429.4	4.0	5.1	19.0	9.0	21.0	10.0	Do.
20	59.5	87.0	1,048.1	1,271.2	3.5	4.3	19.0	9.0	21.0	9.8	Do.
30	56.1	85.0	878.4	1,184.3	3.0	4.1	17.0	7.8	20.5	9.0	Do.
40	46.5	88.5	806.0	1,078.9	2.8	3.7	15.5	6.9	19.3	8.8	Test A. Growth, very poor. Leaves yellowish. Plants slender. Test B. Growth, very poor. Leaves, yellowish. Plants, slender.
50	46.0	95.9	721.5	1,005.4	2.5	3.5	12.5	5.8	18.0	8.0	Do.
(b)	30.0	60.5	567.0	833.8	1.9	2.5	10.0	4.9	16.5	7.0	Test A. Growth, stunted. Leaves, chlorotic. Plants slender. Test B. Growth, stunted. Leaves, chlorotic. Plants slender.

[a] Ordinary garden soil, control.
[b] Volcanic ash.

amount of nitrogen and potassium in the culture medium. Table 3 shows that as the percentage of volcanic ash was increased in the soil mixture there was a gradual decrease in the total amount of nitrogen and potassium in the medium. This was due to the removal of some of the garden soil and its replacement with an equal weight of volcanic ash, the former being richer in nitrogen and potassium than the latter.

The set of cultures in test B which was prepared in the same manner as that of test A except for the method by which the plants were supplied with water (described under preparation and conduction of pot culture) exhibited growth behaviour quite different from that of test A (plates 2 and 4). In test B, the plants grown in the 5-per-cent mixture produced the biggest total leaf product and heaviest dry weight of leaves (tables 4 and 5). Those in the 10-per-cent mixture were a close second and the control plants (grown in garden soil only) were third, then followed in descending order by those in the 20–, 30–, 40–, 50– and 100–per-cent mixtures. In test A, the control plants (grown in garden soil only) were the best, then followed in descending order as the percentage of volcanic ash was increased gradually in the medium. The growth behavior of the tobacco plants in the 5- and 10-per-cent mixtures of test B is interpreted as the influence of the varying amount of soil mixture present in the culture medium caused by the method employed of watering the tobacco plants instead of the decreasing effect of the total nitrogen and potassium in the medium observed in test A. The percentages of soil moisture content of the different culture media used in test B at the termination of the experiment were found as follows: control (garden soil), 33.5; 5-per-cent mixture, 32.1; 10-per-cent mixture, 31.0; 20-per-cent mixture, 30; 30-per-cent mixture, 27; 40-per-cent mixture, 26.5; 50-per-cent mixture, 26.0; and 100-per-cent mixture (volcanic ash only), 24.6. Peralta and Paguirigan(8) pointed out in their previous studies that in the soil a proper balance between the amount of water and air should exist to abound among the roots of tobacco for good growth and that potted tobacco plants grew best when the range of soil moisture in sandy loam soil was between 60 and 70 per cent saturation. Apparently the addition of varying amounts of volcanic ash to garden soil affected the water-absorbing capacity of the garden soil and that the 5- or 10-per-cent mixture brought the soil structure of the medium to an optimum state of condition for water absorption most beneficial

TABLE 5.—*Effect of volcanic ash upon the growth of the tobacco plants grown in pots placed outside of the laboratory (second trial).*

Culture media per cent mixture	Average height		Average total leaf product		Average dry weight of leaves		Average measurements of biggest leaf of 2 plants				Description of plant at end of culture
							Test A		Test B		
	Test A	Test B	Test A	Test B	Test A	Test B	Length	Width	Length	Width	
	cm.	*cm.*	*sq. cm.*	*sq. cm.*	*gm.*	*gm.*	*cm.*	*cm.*	*cm.*	*cm.*	
(a)	25.0	40.7	1,368.6	1,401.2	4.4	5.0	19.0	8.5	19.5	8.6	Test A. Growth, poor. Leaves, pale green. Test B. Growth, poor. Leaves, pale green. Plant, flowering.
5	26.5	43.2	1,352.0	1,482.5	4.3	5.5	19.0	8.5	19.5	8.6	Do.
10	22.5	45.3	1,201.0	1,452.2	4.2	5.2	18.5	8.4	19.0	8.1	Do.
20	30.5	55.8	912.1	1,385.5	3.1	5.0	18.0	8.0	18.5	8.0	Do.
30	20.0	30.5	908.3	1,002.5	3.1	3.4	17.0	7.8	17.1	8.0	Test A. Growth, poor. Leaves, yellowish. Test B. Growth, poor. Leaves, yellowish.
40	23.5	25.4	696.9	773.6	2.4	2.6	16.2	7.2	17.0	7.5	Do.
50	5.5	20.3	462.5	521.6	1.6	1.8	13.0	5.7	13.5	5.8	Do.
(b)	2.0	2.3	209.5	182.7	0.7	0.6	10.2	4.4	9.5	4.6	Plants, stunted. Leaves, chlorotic.

[a] Ordinary garden soil, control.

[b] Volcanic ash.

for tobacco growth when water was supplied the plant subterraneously.

Volcanic ash is beneficial to tobacco plants as indicated by total leaf product and dry weight of leaves.—Cultures 2 and 3 of test C (table 6) contained both the ordinary garden soil and 750 grams each of volcanic ash. Culture 1 was the control and contained only garden soil. The increase in total leaf products and dry weight of leaves of the tobacco plants grown in cultures 2 and 3 to almost two times as much as those in culture 1 was due to the increase in the total amount of the N, P_2O_5 and K_2O content of the medium by 0.075, 3.3, and 3.75 grams, respectively caused by the addition of volcanic ash. Thus, it may be said that the addition of a moderate amount of the volcanic ash to ordinary garden soil improved the nutritive value of the soil beneficial to the growth of the tobacco plant (plate 5). No appreciable difference was noted between the plants grown in cultures 2 and 3, except that the plants in culture 3 had a little bigger leaf area and heavier dry weight of leaves than those in culture 2 (table 6).

TABLE 6.—*Test C showing effect of volcanic ash upon the growth of the tobacco plants grown in pots placed outside of laboratory (third trial).*

Culture No.	Kind and treatment of media used	Average height	Average total leaf product	Average dry weight of leaves	Average measurements of biggest leaf of 2 plants		Condition of plant at end of culture
					Length	Width	
		cm.	*sq. cm.*	*gm.*	*cm.*	*cm.*	
1	Ordinary garden soil (control)	6.7	295.8	1.0	12.0	6.5	Growth, poor. Leaves, pale green.
2	Ordinary garden soil and 2½ cm. thick of volcanic ash placed on the surface of the soil	11.5	509.0	1.7	14.8	7.2	Growth, better than plants in culture 1. Leaves, green.
3	The same as culture No. 2 but volcanic ash was mixed thoroughly with the soil.	11.5	607.9	2.1	14.2	7.2	Do.

SUMMARY

When Mayon Volcano erupted on June 5, 1938, some of its fine ejecta were collected two weeks after from the surface

of the galvanized-iron roofing of houses in the barrios of the municipalities of Guinobatan and Ligao, Albay. The chemical constituents of the volcanic ash were determined quantitatively and it contained the chief constituents of rocks, namely, SiO_2, Al_2O_3, Fe_2O_3, Mn_3O_4, CaO, MgO, K_2O, Na_2O, P_2O_5, and H_2O.

Although volcanic ash analyses showed a very high amount of Al_2O_3 (20.3 per cent), no sign of aluminum toxicity was observed on tobacco plants. On the other hand, the addition of a moderate quantity of volcanic ash to ordinary garden soil proved beneficial to the growth of the tobacco plant.

The usefulness of volcanic ash as a fertilizer, particularly to tobacco plants, may be increased a great deal by the addition of a nitrogen-bearing compound. Nitrogen becomes the limiting major food element in the soil if not supplied artificially.

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ILLUSTRATIONS

PLATE 1

Effect upon the growth of tobacco plants of varying the percentage of volcanic ash in culture medium in pots placed under greenhouse conditions. Plants watered by pouring water on the surface of the medium (first trial, September and October, 1938).

PLATE 2

Effect upon the growth of tobacco plants of varying the percentage of volcanic ash in culture medium in pots placed under greenhouse conditions. Plants watered subterraneously (first trial, September and October, 1938).

PLATE 3

The same as plate 1 except that the plants were placed outside the laboratory (second trial, February and March, 1939).

PLATE 4

The same as plate 2 except that the plants were placed outside the laboratory (second trial, February and March, 1939).

PLATE 5

Effect upon the growth of tobacco plants of adding volcanic ash to an equal weight of ordinary garden soil.

FIG. 1. Garden soil alone.
2. Garden soil and 2½ cm. thick of volcanic ash placed on the surface of the soil.
3. Garden soil and 2½ cm. thick of volcanic ash mixed thoroughly with the soil.

TEXT FIGURE 1.

A portion of the map of the Province of Albay showing the extent of destruction to agronomical crops two weeks after the eruption of Mayon Volcano on June 5, 1938.

PLATE 1.

PLATE 2.

PLATE 3

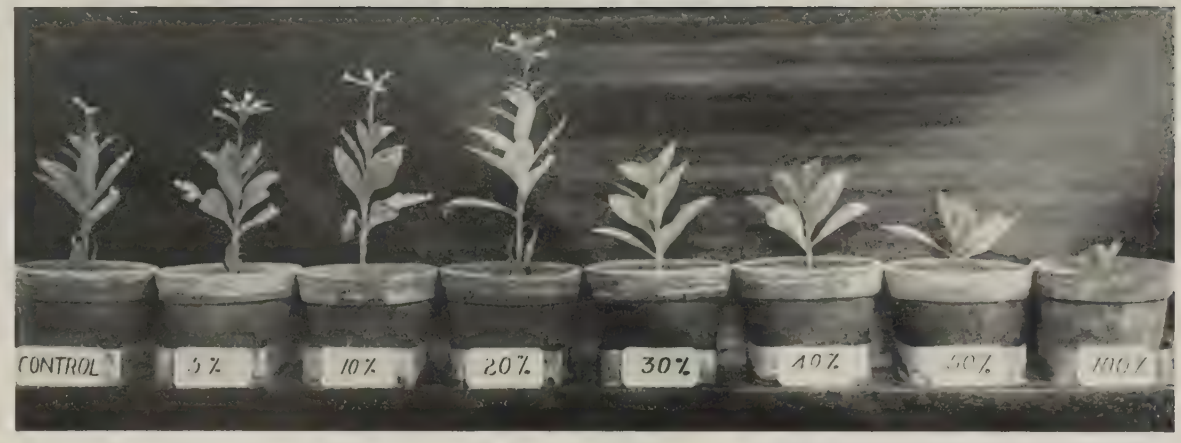

PLATE 4.

PLATE 5.

VARIETAL SUSCEPTIBILITY OF PEANUTS TO BLACK SPOT (CERCOSPORA PERSONATA (B. & C.) Ell. & Ev.)[1]

By Gaudencio M. Reyes and R. Romasanta
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FIVE PLATES AND ONE TEXT FIGURE

The black spot caused by *Cercospora personata* (B. & C.) Ell. & Ev. is one of the most destructive fungus diseases of the peanut (*Arachis hypogaea* Linn.) in the Philippines. It is present wherever peanut is grown, and on account of conspicuity, this disease is generally considered a leaf spot disease, but in reality it attacks also the leaf petioles, stipules, vines, and pegs. Owing to its persistent nature, it occurs frequently in epidemic proportions occasioning severe defoliation, especially during damp weather. Although this disease is generally considered of little economic importance and no attempt has ever been made to evaluate its destructive effects, since commercial growers seem either unconcerned or unaware of its presence, there seems little doubt that the black spot on the leaf alone causes considerable weakening of the affected plants. Aside from the premature shedding of the leaves and petioles induced by the black spot infection, that produced on the main stem and subsidiary vines of the affected plants causes them to become brittle on approaching maturity, and some lead to eventual death. The surviving plants look spindly and the remaining leaves at the top become abnormally small or degenerated due to interruptions in the normal physiological function. On account of the early infection period of the disease, appearing generally a month and a half after planting under field conditions, lasting until harvest time, and the probable aftereffects of the disease, such as possible reduction in yield of fruits and straw, and predisposition to other maladies, some means should be found whereby its ravaging effects could be reduced to the minimum. The future of the peanut as a money crop would seem to hinge largely on the almost total absence of destructive maladies. The black leaf spot alone is mentioned in the literature(9) from all important peanut-growing countries of the world.

Distinct differences in behavior of varieties towards the black spot disease have been observed previously. The object, there-

[1] Received for publication September 9, 1940.

fore, of this investigation is to determine as much as possible the relative susceptibility of peanut varieties to the disease by a method approaching the nearest precision, with the aim of providing data which might be of value to peanut growers and others interested.

HISTORICAL REVIEW

GEOGRAPHICAL DISTRIBUTION AND IMPORTANCE OF THE DISEASE

Judging from the experience of other countries, together with observations made in the Philippines, it may be said that the black spot, caused by *Cercospora personata* (B. & C.) Ell. & Ev.(9), is capable of causing considerable damage. Reinking(4) states that this leaf spot is widely distributed in the Philippines and may become very destructive to some varieties of peanut. In India, where the disease is locally known as "tikka," Butler(3) reports that its prevalence in very severe form was the principal cause of the diminishing yield in groundnut. In Java, as cited by the same author(2), this disease has often wiped out large tracts of groundnut. Butler(2) also cited that the same disease has been commonly seen in German East Africa, Ceylon, and probably in many parts of Asia and Africa wherever peanut is grown. In the United States, Beattie and Beattie(1) report that the black leaf spot of peanut causes appreciable losses. The same disease is also known in China, Japan, and Italy(9) and in the West Indies, Surinam, Paraguay, the Congo, Malaya, and Australia(3).

Wolf(8) made an attempt to correlate the leaf spot of peanut caused by *Cercospora personata* (B. & C.) Ell. & Ev. with yield. This author found out that the leaf spot alone could cause a reduction of 35.07 per cent in active leaf area and an approximate loss in yields of from 5 to 20 per cent was regarded as reasonable.

A thorough survey of the literature and the description of the disease in detail will be dispensed with. Reference to past work will be made here and there in this paper as necessity arises. Mention, however, may be made of a previous and recent work on this disease in the Philippines by Roldan and Querijero(7), which deals mainly with the symptomatology, etiology, epidemiology, and control of the disease. This is the only available paper which has a special bearing on the present work. Their experiments conducted in the College of Agriculture at Los Baños, Laguna, Philippines, with eight varieties of

peanuts showed that all reacted to the black spot in practically the same way, the range of susceptibility being 79.96 ± 2.20 (78.76 ± 2.20) per cent in Santo Tomas to 87.34 ± 2.02 (87.33 ± 2.02) per cent in Valencia variety. The authors concluded that there was no significant difference in the reaction of the eight varieties used to black spot disease.

FIELD OBSERVATIONS

PREVALENCE OF THE DISEASE AND REACTION OF VARIETIES

In view of the prevalence of the black spot disease observed by the senior author in the Central Experiment Station and elsewhere in 1934 and 1935, it was noted that some variation in susceptibility was exhibited, being more destructive in some varieties than in others. A problem, therefore, presented itself as to whether or not a certain degree of resistance would be observed to warrant the planting of fairly high-yielding varieties that can appreciably resist the disease as a control measure.

Ocular examinations of the plat cultures of the Plant Breeding Section, Bureau of Plant Industry, Manila revealed in some way the degree of infection of the peanut varieties with the black spot. The difference in degree of susceptibility was so marked that it could hardly fail to attract attention. Taken at certain intervals, a résumé of these observations showed the following comparative reactions:

TABLE 1.—*Observation on the reaction of some peanut varieties to the black spot during the years 1934–1935.*

Variety name	Degree of infection	Variety name	Degree of infection
Macapno	Very severe.	Singapore	Moderate.
Cagayan	Severe.	North Carolina	Moderate.
Spanish	Severe.	Tirik	Moderate.
White Improved Spanish	Severe.	Valencia	Moderate.
Biit	Moderate.	Vigan Lupog	Moderate.
Georgia Red	Moderate.	Virginia Jumbo (*)	Slight.
Mongoyai	Moderate.	Tai-tau	Slight.
San José	Moderate.	Virginia Jumbo	Resistant.

As shown in table 1, none of the varieties observed was found completely free from black spot infection. The variation in degree of black spot attack was quite evident, ranging from some resistance or slight infection to very severe infection, based largely upon density of spottings and degree of defoliation sustained. Four varieties led by Macapno showed severe in-

fection; nine had moderate infection; while three, all runner varieties, showed only slight susceptibility.

DEFOLIATION DUE TO BLACK SPOT INFECTION

At the early period of infection of the plants, it seems not improbable that a certain degree of incipient damage may have occurred as a direct result of the curtailment in the rate of photosynthesis of an active leaf area. The falling off of the leaves due to the black spot infection (plate 1) takes place in progression (as a gradual process), starting from the lower leaves close to the ground and so on in succession towards the top. The manner by which the shedding off of the leaves occurs was observed as follows: the first pair of pinnae, close to the stem, drops off first, simultaneously or one pinna after the other, leaving the slender leaf petiole intact. Later, the second pair of pinnae at the tip of the petiole follows. This defoliation goes on gradually upwards until the affected vine is nearly or entirely stripped of its foliage. In severe cases of infection, almost the entire frond may drop off in rapid succession. This premature shedding of leaves and subsequent weakening vitality of the affected plants are believed to have some relation with the productive capacity of the plant and the question cropped up as to whether or not it may ultimately have disastrous effect on yield. As an instance of this, some defoliated plants gave little yield whereas in some plants or in some varieties defoliation resulted in death.

INFECTION OF VINES AND PEGS

Aside from the black spot affections involving the aërial parts, such as leaves, leaf petioles (plate 2), and stipules, the infection of vines and pegs causes serious handicaps in the normal functioning of the plant and distribution of food materials. The gynophores having typical stem structures, if they get infected, especially at an early stage, sustain as much adverse effects as those received by the genuine stems (plate 3), because of continuity of vehicular activity, and the passage of food materials is virtually hampered by destruction or malformation of necrotic tissues. The root system being that of the tap root type, the aërial portions are also subject to black spot infection. Much more serious perhaps in effect of all black spot infections is that produced on the pegs (plate 4) as it directly obstructs the conveyance of elaborated food needed in the normal develop-

ment of the underground parts, the pods especially, which are of material value from the agricultural aspect. The infection of some of the pegs, therefore, could cause irregular maturity of the pods; many of them having been observed to be relatively small, generally one-seeded and immature.

POSSIBILITY OF CONTROL BY VARIETAL RESISTANCE

To the knowledge of the writers, very little attention has ever been paid towards the control of peanut black spot in the Philippines. From the results of experiments obtained in the Philippines, Roldan and Querijero(7) stated in unmistakable terms that "the control of the disease is a difficult matter." In their paper they presented an observation on black spot infection of eight varieties of peanut at the College of Agriculture, Los Baños, Laguna, and concluded that all the varieties tested showed practically the same degree of susceptibility. In view of the lack of information on the method of controlling this disease which prevails everywhere from season to season or year after year, this paper is now presented with the hope that it would be of some practical value to the farmers.

Judging from available foreign literature, there seems to be no known feasible method of control recommendable for the black spot disease of peanut. Wolf(8), and Roldan *et al.*(7) state that seed disinfection and crop rotation are impracticable because the disease is claimed to be not seed-borne; that the black spot organism persists on peanut refuse or decaying or dead leaves scattered in the soil from season to season; and that the spores can be readily spread from field to field by air currents and certain insects, especially those that feed on diseased leaves, and by other mechanical agencies. Considering the previous results, as a rational control measure, the writers believe that the infected fields should better be not planted to peanuts in succession. In a much earlier work than that of Roldan *et al.*(7), Wolf(8) had demonstrated clearly the inefficacy of rotation as a method of control for the same disease. Butler's work(2) in India showed that spraying with Bordeaux mixture was not satisfactory because the aërial portions of the fungus were developed on the nether surface of the leaves and were thus difficult to contact with the fungicide. From the above considerations, it seems now clear that the only possible panacea for this peanut malady is the planting of varieties that can withstand the devastating effects of the disease.

MATERIALS AND METHODS

In order to determine the behavior of varieties to the black spot, 100 plants each of 13 varieties were planted in two replications in heavily infested plats, measuring 1 meter x 5 meters, provided with a half meter dead space, and the seeds were planted 30 centimeters in the row and 40 centimeters between rows. To estimate the degree of infection to the nearest precision, actual counts of the leaf spottings were made per unit area ($\frac{3}{4}$ inch square) of leaf surface taken at three definite, fortnightly intervals, covering a period from early infection or when all varieties showed appreciable black spot infection to the peak of greatest susceptibility. The last 2 readings were made from 40 different leaves of all stages, that is, young, middle age, and mature, while in the first only 32 leaves were used, selected at random from the peanut plants where not a single individual showed complete freedom from the disease, and the spots were recorded with the aid of a mechanical hand tally counter. The use of different stages of leaves from different uniformly mature plants was necessary so as to include all the active leaf area engaged in photosynthetic activity.

RESULTS

The results of this study are given in table 2.

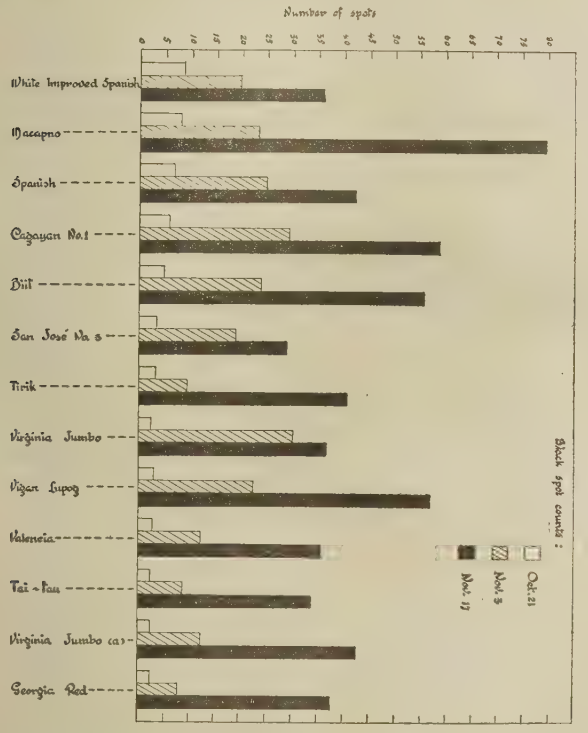
TABLE 2.—*Black leaf spot counts on thirteen peanut varieties taken at three intervals of time.*

Variety of peanut	Number of spots			
	Oct. 21 [a]	Nov. 3 [b]	Nov. 17 [b]	Average of three counts
White Improved Spanish	8.68	19.70	35.92	21.45
Macapno	8.09	23.32	79.50	36.97
Spanish	6.71	24.77	42.20	24.56
Cagayan No. 1	5.75	29.20	58.87	31.27
Biit	4.78	23.85	55.62	28.08
San José No. 3	3.34	18.70	28.72	16.92
Tirik	3.21	9.37	40.55	17.71
Virginia Jumbo	2.46	30.00	36.65	23.03
Vigan Lupog	2.93	22.42	56.90	27.41
Valencia	2.68	12.05	35.65	16.76
Tai-tau	2.28	8.60	38.82	14.92
Virginia Jumbo (*)	2.31	12.35	43.62	19.42
Georgia Red	2.31	7.75	37.67	15.91

[a] Average of 32 readings. [b] Average of 40 readings.

From the preceding data it can be readily seen that the degree of infection increases as the sources of natural inoculum in-

crease in proportion, and in all cases the rate of infection is in progression. The height of greatest susceptibility becomes more apparent during the senescent period of growth, when the plant uses most of its resources in the development of the pods. That all varieties under study were susceptible to the black spot infection is a foregone conclusion; but that varieties differ in susceptibility to the disease seems also clear after a preliminary observation. The writers, however, believe that it would require



Text figure 1.—Graphic representation of the fortnightly counts of the black spot (*Cercospora personata* (B. & C.) Ell. & Ev.) on the leaves of thirteen varieties.)

a large number of cultures, following the same method of study conducted in from three to five seasons before we can fully appreciate their worth.

In determining the degree of susceptibility, however, the averages of the three fortnightly counts were made and these show the rank of susceptibility in the following descending order: Macapno, Cagayan No. 1, Biit, Vigan Lupog, Spanish,

Virginia Jumbo, White Improved Spanish, Virginia Jumbo(a), Tirik, San José No. 3, Valencia, Georgia Red, and Tai-tau.

In the first counts made on October 21, 1936 (fig. 1), of black spots on the leaves, all the thirteen varieties showed susceptibility in a more or less uniform degree; White Improved Spanish, Macapno, Spanish, Cagayan, and Biit showing slightly more infections than the rest of the varieties studied, or about 5 to 8 black spots per ¾ inch-square of leaf area. The second fortnightly counts of the leaf spot revealed a similar range of susceptibility with rather abrupt changes in Cagayan No. 1, Biit, Virginia Jumbo, Spanish, Macapno and Vigan Lupog. In the third count, however, or during the period when the differences in susceptibility became more apparent, the extent of black spot infections ranged from 28.72 in San José No. 3 to 79.5 in Macapno. At this stage of growth increased infection was very marked on the varieties Macapno, Cagayan No. 1, Biit and Vigan Lupog. From the results of this study it seems now quite evident that four of the varieties can be classed as highly susceptible, namely, Macapno, Cagayan No. 1, Vigan Lupog, and Biit; six varieties fall in the order of moderate susceptibility; while two may be considered resistant varieties, viz., San José No. 3 and Tai-tau. This appraisement seems to deviate but slightly from the computed averages. In a three-year work on peanut(5) conducted by the senior author, Tai-tau was one of the runner varieties which was found to have consistently shown considerable resistance to black spot infection besides being a high yielder.

ECONOMIC EFFECT OF THE DISEASE

The economic importance of the black spot disease cannot be appreciated until after 2 to 3 plantings have been made continuously in the same field not previously grown to peanut. Although this disease has been observed to cause severe defoliation and spindling in some varieties, and deterioration of nut was manifest, largely by virtue of the food supply having been partially cut off through the infection of vines and pegs, no exact figures could be given to substantiate the claim. The lack of adequate relative expression might be explained by the fact that the deferred death of the plants due to black spot infection occurred generally at the senescent period, so that no substantial positive effect would result therefrom after the pods have already formed and are only awaiting the period of maturation.

An evaluation, however, of the bad effects of the disease was adequately explained by Butler(3) in the following paragraph:

> Naturally, when the attack begins early, the plant is unable to mature its nuts. Those that have begun to form as the attack reaches its height, cease development, and at harvest are found shrivelled and loose in the shell. If they have reached a certain stage of maturity before the disease becomes severe, the reduction of the total yield of nuts is less marked, as the loss of leaf occurs too late to check their development. In many cases, however, losses of from one-third to one-half have occurred in infected fields.

That the decline of groundnut production in the Bombay Presidency, as reported by Butler(2), seemed to be due to the disastrous effects of the black spot disease is supported by the fact that the incidence of "tikka" disease, caused by *Cercospora personata*, "was at its height when the exports from Bombay were at their lowest figure, and that the recovery has coincided with the disappearance of the disease."

In Senegal, an overseas possession of France in West Africa, Roger(6) states that, because of humid conditions, the peanuts that were introduced from Nigeria became very susceptible to black spot and as a result they had to be destroyed, yielding no crop at all.

The black spot produced on the vines has also a detrimental effect for it hastens maturity and renders the vines brittle, thus making them unsuitable or unpalatable perhaps for animal feed.

SUMMARY AND CONCLUSIONS

1. The black spot of peanut is an omnipresent disease of this valuable crop. The causal fungus, *Cercospora personata* (B. & C.) Ell. & Ev., is an obligate parasite and has not been observed to occur here on other host plants.

2. Its incidence on the leaf, leaf petiole, stipule, and stem has been reported by previous investigators. Through diligent search, the black spot disease was also found to infect the pegs, another vital organ of the peanut plant heretofore unknown to the writers.

3. Certain varieties of peanut show a marked difference in resistance. Black spot counts on the leaf revealed that they differ among varieties, ranging from 2.28 per $\frac{3}{4}$ inch square, at the initial infection period, to 33.82 for the same leaf area, at the time of greatest prevalence, in Tai-tau; and 8.09 to 79.50 in Macapno. The method of study here developed seems to be

sufficiently explicit in determining with good approximation the grades of black spot infection.

4. It was determined from this study that the varieties Taitau, Georgia Red, Valencia, San José No. 3, and Tirik exhibited better resistance to black spot than the other varieties in the order named. The practical side of this paper would be to show in concrete terms to the growers the damage caused through the planting of susceptible varieties in infested localities. The continuous or inadvertent planting of ill-adapted varieties that are very susceptible to the disease will in some way or another cause losses.

5. The black spot materially reduces the healthy leaf area before the pods are fully developed. The attack on the stem and peg has a much more serious influence upon the crop than the leaf spot. Although the affected plants very rarely die, they are as a rule very much weakened under field conditions.

6. Without being optimistic in the least, it seems quite probable that by the introduction and acclimatization of exotic sorts or by breeding and selection, varieties or strains possessing desirable economic traits that could resist the ravages of the disease would eventually be evolved which would contribute some efficiency and economy in our method of control. The differences in reaction observed afford a sufficient basis on which to evolve a higher degree of resistance.

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ILLUSTRATIONS

(Photographs by the Photographic Studio, Bureau of Science, Manila)

PLATE 1

Black spot of peanut caused by *Cercospora personata* (B. & C.) Ell. & Ev. on the leaves of Spanish variety; upper and lower surfaces. Approximately x 0.9.

PLATE 2

Peanut leaf petioles and vines showing black spot affection (*Cercospora personata* (B. & C.) Ell. & Ev.). Note the elliptical spots on the petioles (*a*), × 1.2, and on the stipules(*b*) and main stems(*c*), about × 2.

PLATE 3

Peanut vines and tap roots affected by the black spot (A). Note the tufts of conidiophores on the stems (B) and elsewhere. Approximately × 2.

PLATE 4

Pegs of peanut showing the black spot on various parts pointed by arrows, appearing more distinctly in the photograph at X. Approximately × 1.45.

PLATE 5

Portions of vines, and pegs of peanut attacked by the black spot, showing pods which have been probably arrested in development by infection. Arrows show probable origin by contact, and the braces show black spot infections. Approximately × 1.1.

TEXT FIGURE 1.

Graphic representation of the fortnightly counts of the black spot (*Cercospora personata* (B. & C.) Ell. & Ev.) on the leaves of thirteen varieties.

PLATE 1.

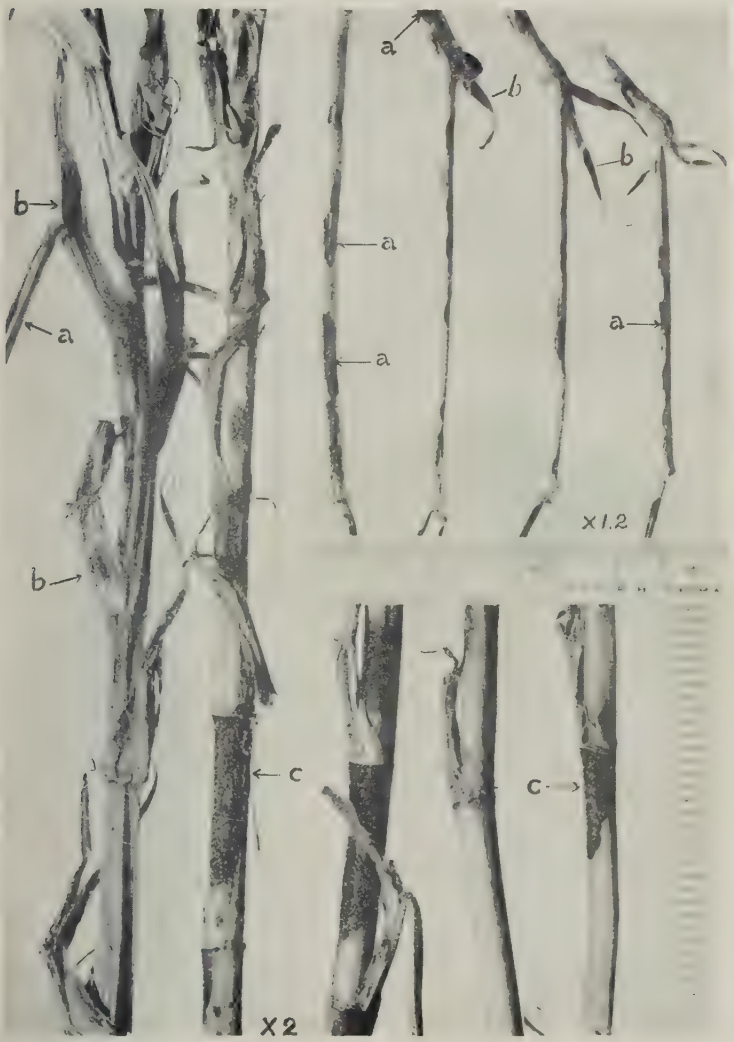

PLATE 2.

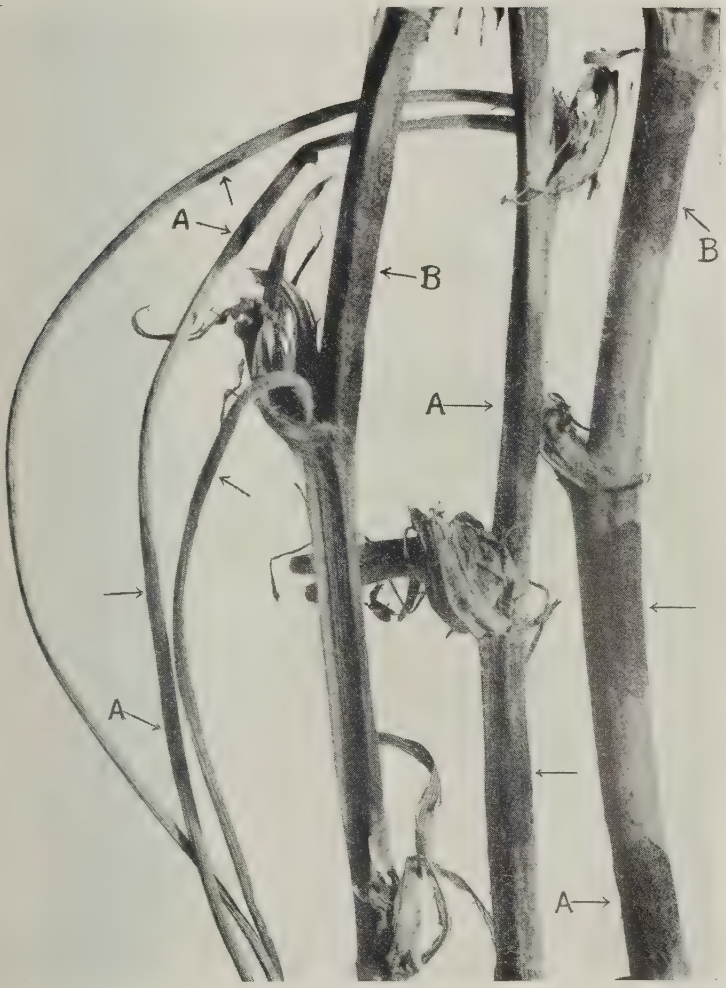

PLATE 3.

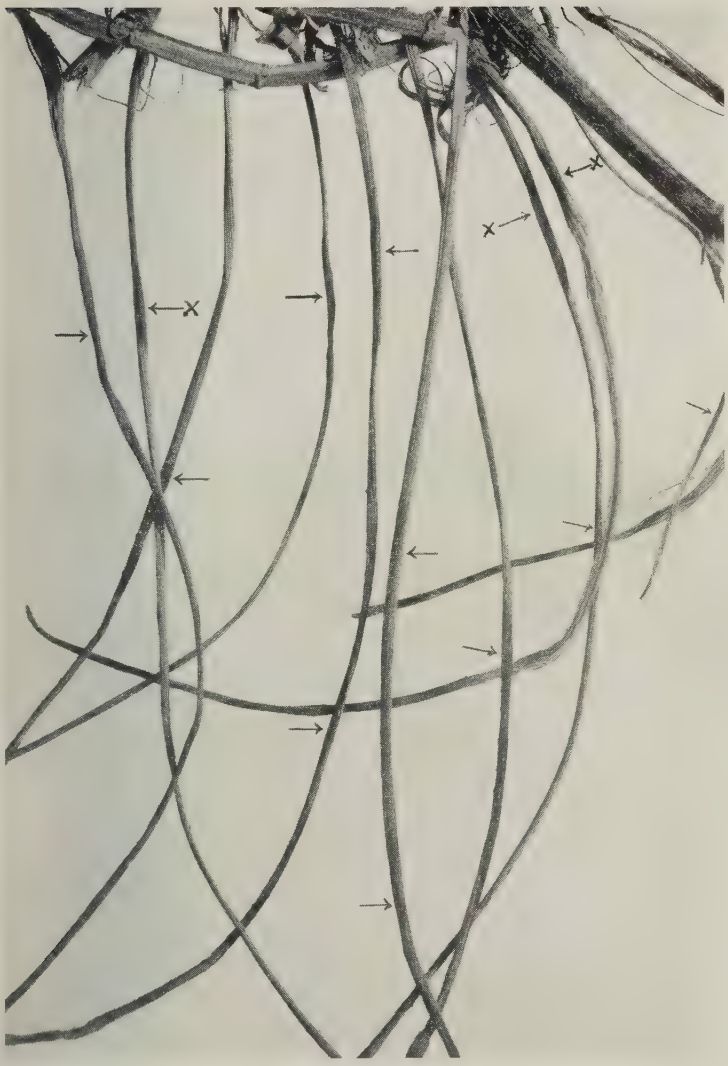

PLATE 4.

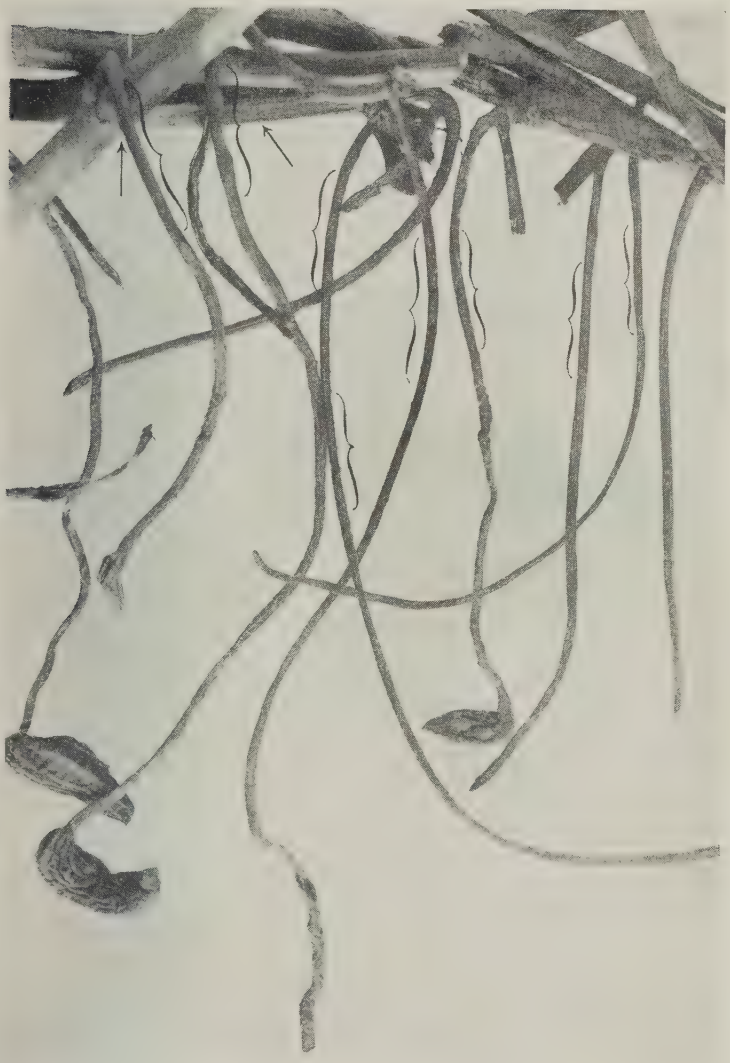

PLATE 5.

STORING SOME VEGETABLE SEEDS [1]

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Of the Horticulture Section, Bureau of Plant Industry

FIVE TEXT FIGURES

With the increasing interest in the growing of vegetables, it has also become more apparent that success in their culture is greatly predicated upon good and viable seeds. Unfortunately, however, the temperature and moisture conditions in the Philippines, practically throughout the year, are conducive to rapid deterioration of seeds. Experience bears the fact that vegetable seeds especially those imported from temperate countries lose their viability very rapidly. If there is any complaint against any local seed house, it is invariably because of the fact that in general the seeds it handles have poor germination. This is due, in almost all cases, to defective storing. Any study therefore that may throw some practical information on the proper storing of vegetable seeds should be of great value to vegetable growers as well as to seed houses and scientific workers.

Following the lead pointed out by Vibar and Rodrigo (10) in their studies on the storing of farm crop seeds, it was the object of the present study to determine the practicability and efficacy of storing vegetable seeds in air-tight containers. Heretofore, the Plant Propagation Division of the Bureau of Plant Industry had been keeping its seeds for distribution to the public in cold storage. While this method may be effective, it is not within the reach of the farming public. The method used in this study is simple yet practical and can be used easily on the farm. The study was undertaken in the laboratory of the Horticulture Section, Bureau of Plant Industry, Manila from June, 1935 to November, 1938.

REVIEW OF LITERATURE

Numerous papers dealing either directly or indirectly with seed biology and seed storage have been published. Most of the experiments, however, have been worked out in temperate countries and only a comparatively few in the tropics. It is

[1] Received for publication June 26, 1940.

not attempted here, however, to make an exhaustive review of these works but only to cite some of those that have direct bearing on the present study.

As early as 1904 Duvel(1 and 2) reported that in his studies on the storage of sweet corn, onion, cabbage, radish, carrot, pea, bean, watermelon, and lettuce seeds, he found that the viability of the seeds was directly proportional to the amount of rainfall in the district where they were stored, the injury becoming more pronounced as the temperature became higher. He established the fact that there was a close relationship between the loss of viability and the increase of moisture, the effect increasing with a rise of temperature both in the sealed and open bottles and packages.

Toole and Brown(9) listed insect injury, high temperature and high moisture as limiting factors affecting the life of the seed. They stated that seed would endure a relatively high moisture if the temperature was low but not freezing, and relatively high temperature if the moisture content was kept low. A combination of both induces rapid respiration, resulting in a rapid destruction of the viability of the seeds. They concluded that when seed was produced in a moist climate, it retained a high percentage of moisture and when kept in shipboard for a long time as in the case of imported seed, it lost its viability rapidly when brought into a warm country.

The work of Heinrich(4) on the influence of atmospheric moisture, temperature and oxygen of the air on stored seeds showed that although such seeds were high in hygroscopic water content they were able to retain their viability for a longer period when fresh air was admitted than when there was no ventilation. Previous drying of the seeds did not prolong their viability if there was free access of air, but when artificially dried-stored in air-tight containers, the viability of the seeds was greatly prolonged even at high temperature (30° C.). Low temperature (below 5 C.), without exception, prolonged the viability of the stored seeds even though they contained a large amount of hygroscopic moisture. Guillaumin(3) reported that dryness and reduction of air pressure prolonged the germinability of seeds while Tillotson(8) obtained the best germination from seeds stored in localities of high altitude but of low relative humidity.

Vibar and Rodrigo(10) in their work on the storing of some farm crop seeds in the Philippines found that seeds stored in

sealed containers with and without naphthalene remained strongly viable from two to four or more years while those in cloth bags lost their viability in less than a year, with a few exceptions. Rodrigo(5), continuing the work above mentioned, reported that some of the bean seeds stored in air-tight containers remained viable for over 11 years.

San Pedro(7) of the College of Agriculture, U. P., Agricultural College, Laguna in his work on the influence of moisture and temperature on the viability of some vegetable seeds found that the former factor (moisture) exerted more influence on the viability of the seeds than the latter (temperature).

MATERIALS AND METHODS

Ten different kinds of vegetable seeds were used in this study. These were Surehead cabbage, *Brassica oleracea* var. *capitata* L.; Early Patna cauliflower, *Brassica oleracea* var. *botrytis* L.; Chinese pechay, *Brassica cernua* Tumb.; Chinese long radish, *Rhaphanus sativus* L.; Big Boston lettuce, *Lactuca sativa* L.; Yellow Bermuda onion, *Allium cepa* L.; Japanese purple eggplant, *Solanum melongena* L.; Bontoc pepper, *Capsicum frutescens;* Mary Washington asparagus, *Asparagus officinalis* L.; and cucumber, *Cucumis sativus* L. The seeds of cabbage, cucumber, and lettuce were imported from the United States; those of onion from the Canary Islands; those of cauliflower from India; and those of radish and pechay from China; while those of asparagus, eggplant and pepper were produced at the Lipa Citrus Experiment Station, Lipa, Batangas. With the exception of those locally produced which were harvested a little over one month before the experiment was started, no information is available about the date of their harvests. It is assumed that they were comparatively new.

Before storing the seeds, each kind was thoroughly mixed and samples were taken for the determination of their initial germination. The seeds were then thoroughly dried in an electric oven with a temperature ranging from 45° to 50° C. for about two days. Likewise the vials (9 cm. long, 1.5 cm. in diameter) which were to be used as containers were also dried in the oven.

The seeds were put in the vials while still warm. Each kind of the ten vegetable seeds was represented by 80 sealed and 12 unsealed vials. Thus, the seeds were stored (1) under air-tight condition and (2) under the influence of air and its

relative humidity. The sealing of the seeds was accomplished by dipping the corked end of the vials in melted paraffin. These were labeled, arranged in a box and kept in the laboratory of the Horticulture Section, Bureau of Plant Industry.

The seeds of pepper and asparagus were stored on June 16 and 19, 1935 respectively; those of radish, cabbage, pechay, lettuce, cucumber, and onion on June 25, 1935; while those of cauliflower and eggplant were stored on August 14, 1936. The monthly testing of the viability of the different seeds was made every 21st of the month. In the event that the 21st was either Sunday or holiday, the testing was advanced or delayed one or two days as indicated in the results. A vial was opened only when seed samples were taken for germination test after which such vial although immediately sealed was separated from the experimental vials. One vial each of the sealed and unsealed seeds of each kind was weighed every month to determine the loss or gain in weight if there was any.

In the germination tests, a soil medium composed of fine sand and loam soil put in a seedbox was used. The soil was kept moist during the tests. Enough time was given the seeds to germinate after which the seedlings were pulled off and counted. For some time after this, the box was watered for further observations on germination. As a rule, it took from 10 to 15 days to complete the observation on one monthly test. After this, the soil medium was thoroughly stirred and dried for future use.

EXPERIMENTS AND RESULTS

The study was started on June 25, 1935 and the last germination test was made on November 21, 1938, covering a period of 41 months. At the close of the experiment, some of the seeds in the sealed vials were still highly viable. The seeds in the unsealed vials lost their viability quite early. Table 1 presents the results of the monthly germination tests throughout the duration of the experiment. Table 2 is a summary of table 1, while table 3 shows the gain or loss in weight of the seeds during the progress of the study.

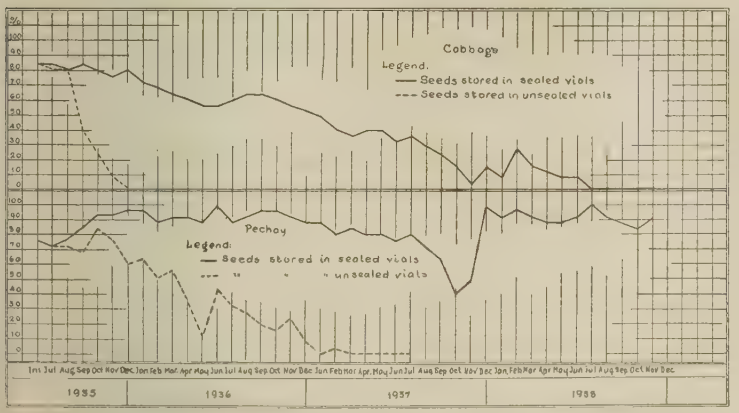
Graphs 1 to 5 were made to show in a vivid manner the trend of the viability of the seeds of the different vegetables as stored in sealed and unsealed containers.

DISCUSSION OF RESULTS

As may be seen in table 1, the viability of the seeds used in this study was greatly dependent upon the kind of seed and

upon the method of storing employed. In all cases, the loss of viability was very rapid with the seeds that were kept in unsealed vials where they were affected by the relative humidity of the air. On the other hand, the seeds that were kept in

Text FIGURE 1.



Text FIGURE 2.

sealed containers were able to maintain their viability much longer as will be shown later.

Seeds stored in unsealed vials.—As already stated, the seeds kept in unsealed vials lost their viability within a comparatively short period. For example, the cabbage and lettuce seeds began to be critical in their viability in three and four months,

TABLE 1.—*Monthly germination of 10 kinds of vegetable seeds stored in unsealed and sealed vials.*

Date test made	Radish		Cauliflower		Cabbage		Pechay		Lettuce		Cucumber		Onion		Asparagus		Eggplant		Pepper	
	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed
1935	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Initial germination	96	96	88	88	84	84	76	76	67	67	64	64	76	76	88	88	80	80	92	92
July 20	96	96	-----	-----	80	84	72	72	68	68	60	60	72	72	88	92	-----	-----	92	92
August 21	92	96	84	88	80	80	72	76	60	68	64	68	64	80	84	88	80	80	88	88
September 21	88	96	80	88	40	84	68	84	60	72	64	64	72	76	84	96	80	84	84	84
October 21	84	96	80	92	24	80	84	92	52	76	56	60	68	76	80	92	76	84	76	88
November 21	64	88	72	84	8	76	76	92	20	72	32	64	60	80	76	92	76	88	72	88
December 21	56	92	56	88	0	80	60	96	0	68	32	64	56	84	84	96	40	80	36	92
1936																				
January 21	52	92	32	84	0	72	64	96	4	68	24	56	52	84	80	84	48	84	36	84
February 21	52	88	12	80	0	68	52	88	0	72	12	60	48	88	80	88	64	88	28	96
March 21	48	84	0	88	0	64	56	92	0	64	4	56	16	84	72	92	60	88	32	96
April 21	48	88	8	88	0	60	36	92	0	68	8	52	0	80	64	88	56	92	20	92
May 21	40	92	0	92	0	56	12	88	0	64	0	44	8	76	56	80	60	92	12	88
June 20	32	84	0	96	0	56	44	100	0	56	4	48	4	80	60	88	52	92	4	88
July 21	24	88	0	96	0	60	32	88	0	56	0	44	0	80	44	84	56	96	0	92
August 21	28	92	0	92	0	64	28	92	0	60	0	60	0	72	28	92	60	88	4	84
September 21	20	96	0	80	0	64	20	96	0	52	0	56	0	76	16	84	48	98	0	84
October 21	16	96	0	88	0	60	16	96	0	44	0	48	0	68	16	84	40	84	8	92
November 21	8	88	0	84	0	56	24	92	0	36	0	48	0	60	12	80	24	92	0	84
December 21	0	92	0	72	0	52	8	88	0	40	0	40	0	40	4	76	32	88	0	84
1937																				
January 21	0	84	0	68	0	48	0	88	0	40	0	32	0	44	0	76	16	84	0	88
February 20	4	84	0	72	0	40	4	80	0	32	0	24	0	36	8	80	0	80	0	80
March 22	0	80	0	60	0	36	0	84	0	40	0	24	0	24	0	72	8	72	0	84
April 21	0	76	0	68	0	40	0	80	0	48	0	16	0	8	0	76	0	76	0	76
May 21	0	68	0	64	0	40	0	80	0	16	0	12	0	0	0	80	0	68	0	72
June 21	0	60	0	56	0	32	0	76	0	0	0	20	0	4	0	84	0	64	0	76
July 21	0	56	0	60	0	36	0	80	0	12	0	8	0	0	0	88	0	72	0	68
August 21	0	52	0	64	0	28	0	72	0	8	0	4	0	4	0	84	0	76	0	64

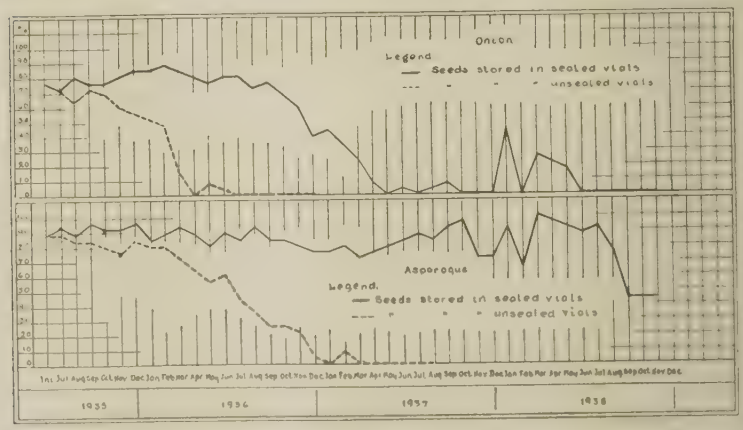
September 21	0	44	0	60	0	24	0	64	0	0	0	4	0	8	0	92	0	80	0	52
October 21	0	60	0	52	0	16	0	40	0	0	0	12	0	0	0	96	0	64	0	68
November 22	0	72	0	28	0	4	0	48	0	0	0	4	0	0	0	72	0	80	0	68
December 21	0	72	0	40	0	16	0	100	0	0	0	0	0	0	0	72	0	28	0	84
1938																				
January 21	0	44	0	40	0	8	0	92	0	0	0	0	0	44	0	92	0	40	0	80
February 21	0	40	0	80	0	28	0	96	0	0	0	20	0	0	0	64	0	0	0	92
March 21	0	44	0	76	0	16	0	92	0	0	0	12	0	16	0	100	0	0	0	84
April 21	0	40	0	72	0	12	0	88	0	0	0	16	0	12	0	96	0	0	0	80
May 21	0	36	0	60	0	8	0	88	0	0	0	0	0	8	0	82	0	0	0	66
June 22	0	20	0	80	0	8	0	92	0	0	0	4	0	0	0	88	0	0	0	64
July 21	0	16	0	96	0	0	0	100	0	0	0	0	0	68	0	92	0	44	0	92
August 22	0	12	0	72	0	0	0	92	0	0	0	8	0	0	0	76	0	0	0	76
September 21	0	0	0	56	0	0	0	88	0	0	0	0	0	0	0	44	0	60	0	92
October 21	0	0	0	0	0	0	0	84	0	0	0	0	0	0	0	44	0	54	0	82
November 21	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	44	0	60	0	52

TABLE 2.—*A summary of table 1, giving the comparative longevity of different vegetable seeds when stored in sealed and unsealed containers.*

Name of seed	Number of days to germinate	Number of months from storing to:			
		Unsealed vials		Sealed vials	
		Viability critical	Viability lost	Viability critical	Viability lost
Radish	3– 6	10	18	21	39
Cauliflower	4– 6	6	11	37	39
Cabbage	2– 5	3	6	23	37
Pechay	3– 7	10	21	[a] 41	
Lettuce	3– 9	4	8	17	27
Cucumber	3– 7	5	13	17	39
Onion	4– 9	8	13	15	38
Asparagus	5–12	14	21	38	[a] 41
Eggplant	4–10	13	21	28	[b] 40
Pepper	4– 8	6	17	[b] 41	

[a] At this period, the seed was still strongly viable.
[b] At this period, the seed was still giving a fair viability.

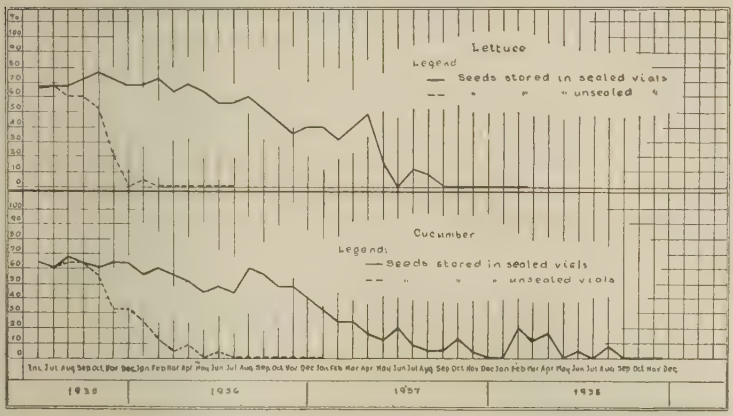
respectively after storage; cauliflower and cucumber in six and five months, respectively; pepper in six months; onion in eight months; radish in ten months; pechay in ten months and eggplant and asparagus in thirteen and fourteen months, respec-



TEXT FIGURE 3.

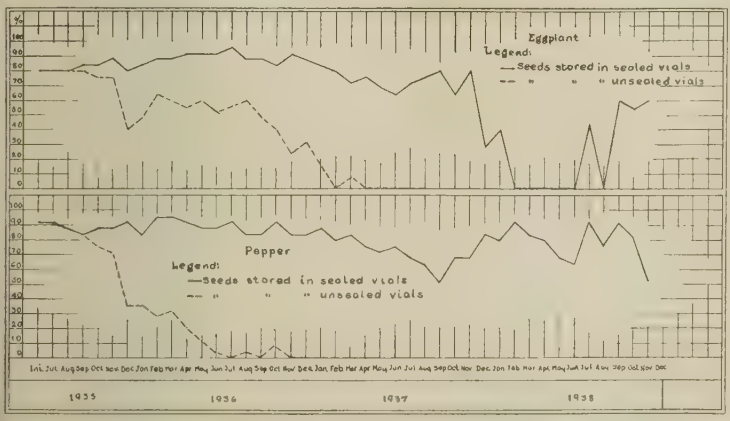
tively. The deterioration of the seeds in the unsealed vials was rapid after their viability became apparently critical. The cabbage completely lost its viability after six months; cauliflower in 11 months; cucumber in 13 months; pepper in 17

months; onion in 13 months; lettuce in 8 months; radish in 18 months; asparagus, eggplant, and pechay in 21 months. In this connection it may be stated that a corked vial is a better storing receptacle than either cloth or paper bag, the common containers



Text FIGURE 4.

used by local seed dealers. The viability of seeds stored in the latter containers is lower.



Text FIGURE 5.

According to table 3, the seeds stored in unsealed vials gained in weight ranging from 0.4 to 1.1 grams per vial within a period of one year, while those in the sealed vials did not gain in

weight with the exception of radish and cucumber which gained 0.1 and 0.2 grams per vial, respectively. The increase in weight must have been due to the absorption of moisture from the air.

TABLE 3.—*The gain (+) or loss (—) in weight by months of different vegetable seeds stored in unsealed and sealed containers.*

Date test made	Radish		Cauliflower		Cabbage		Pechay		Lettuce	
	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed
	gm.	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
7–21–35	0.3	0.0	0.0	0.0	0.4	0.0	0.1	0.0	0.0	0.0
8–21–35	0.2	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.1	0.0
9–21–35	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0
10–21–35	0.0	0.1	0.3	0.0	0.1	0.0	0.1	0.0	0.1	0.0
11–21–35	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0
5–21–36	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6–21–36	0.0	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.1	0.0
7–21–36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total gain or loss	0.7	0.1	0.8	0.0	1.0	0.0	0.8	0.0	0.5	0.0

Date test made	Cucumber		Onion		Asparagus		Eggplant		Pepper	
	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed	Unsealed	Sealed
	gm.	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm*
7–21–35	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0
8–21–35	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3	0.0
9–21–35	0.1	0.0	0.3	0.0	0.1	0.0	0.1	0.0	0.1	0.0
10–21–35	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11–21–35	0.1	0.0	0.3	0.0	0.2	0.0	0.2	0.0	0.1	0.0
5–21–36	0.1	0.2	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.0
6–21–36	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7–21–36	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Total gain or loss	1.1	0.2	1.0	0.0	0.8	0.0	0.4	0.0	0.8	0.0

The increased moisture content of the seeds was the cause of the rapid deterioration of their viability. This finding corroborates the findings of Duvel(2) and of Heinrich(4).

Seeds in sealed vials.—The different seeds that were kept in sealed vials were able to keep their viability much longer than their counterparts which were kept in unsealed but corked vials (table 1). This finding corroborates the results of Vibar and Rodrigo(10) in their study of the storing of some farm crop seeds and of Heinrich(4) in which they found that keeping seed in air-tight containers was a much more efficient way of preserving the viability of seeds.

This finding should be of great value to gardeners as well as to seed houses and scientific workers. It reduces seed storage to a simple, practical, economical but still efficient method.

The shortest-lived seed in the sealed vials lasted 27 months in storage before it completely lost its viability as compared with the six months of the shortest-lived seed in the unsealed vial. The longest duration attained by the seeds in unsealed vials was that of eggplant and pechay seeds and these lasted 21 months only, shorter by six months when compared with the shortest lived in the sealed containers. Text figures 1 to 5 show in a vivid manner the trend of the viability of the seeds stored in sealed and unsealed vials. It is conclusively shown that seeds which were not affected by the humidity of the air while in storage kept their viability much longer—from 190 to over 720 per cent.

The range in the longevity of the seeds in the sealed vials varied from 27 months to over 41 months. The lettuce seeds completely lost their vability after 27 months in storage; cabbage after 36 months; onion after 38 months; cauliflower, radish and cucumber after 39 months; asparagus after 40 months. Eggplant, pechay, and pepper were still germinating after 41 months in storage.

A further study of table 1 will show some interesting phenomenon which as far as the writers have been able to ascertain only one investigator has made mention of (5). Reference is made to the rise in the percentage of germination of most of the seeds after they have shown some signs of weakness in their germination. This rise in the percentage of viability is well illustrated in the graphs herewith presented, particularly in the case of pepper, eggplant, onion, pechay, cauliflower and radish. For example, pechay, after the 17th month in storage, gradually began to show weakening of viability until the 28th and 29th months when its germination went down to 40 and 48 per cent. After this, the seed again showed very strong viability up to the 41st month when this experiment was closed, the germination ranging from 84 to 100 per cent with an average of 92 per cent for a period of 12 months. Such was also the case with the other seeds studied although this renewed vigor was manifested in a lesser degree. The fact that all the seeds used in this study manifested in a greater or lesser degree some striking evidence of renewed vigor of viability without any change of treatment seems to make the claim of Rodrigo (5)

stronger that "this renewed life activity after a period of semi-dormancy" . . . "is a natural phenomenon manifested in many other ways in the life of both plants and animals." His recent findings that 13-year-old mungo (*Phaseolus aureus* Roxb.) seeds produced more beans than 1-month-old seed (6) is another striking manifestation of this seemingly natural yet little known phenomenon.

SUMMARY OF CONCLUSIONS

The results presented in this study seem to justify the following conclusions:

1. The viability of the seeds was dependent upon their kind but was greatly affected by the method of storage employed.

2. Seeds stored in corked but unsealed vials lost their viability within a very much shorter length of time than those that were stored in sealed or air-tight vials. The latter seeds remained viable about 190 to 720 per cent longer than the former.

The seeds in unsealed vials began to be critical in their viability in three to 12 months after storage and completely lost their viability in six to 21 months, while those in air-tight containers did not lose their viability until after 27 to over 41 months in storage.

3. The rapid loss in viability of the seeds in unsealed containers was due to the absorption of moisture, which naturally must have started some degree of metabolism.

4. An interesting phenomenon was found on the behavior of the seeds kept in sealed vials. In a lesser or greater degree, they manifested a striking evidence of renewed vigor in their viability after they have become critical in their germination.

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48721——5

ON CHRISTISONIA WIGHTII ELMER, A PARASITE OF SUGARCANE [1]

By Eduardo Quisumbing

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TWO PLATES

Christisonia Wightii Elmer is the only representative of this genus reported from the Philippines and is known only from the Archipelago. Of the sixteen species known to science up to 1925, thirteen occur in India proper and Ceylon, one in Thailand (Siam), one in the Malay Archipelago, and one in the Philippines. It was originally collected by Mrs. M. S. Clemens, on April 16, 1907, from Camp Keithley, Lanao Province, Mindanao, but was first described by Mr. A. D. E. Elmer from material collected by him near Dumaguete, Oriental Negros Province, in the island of Negros. The plants were found growing in rich damp ground among tussocks of *Amomum fusiforme* Ridl. along the upper edge of a deep ravine at 1,750 feet elevation. It is known in the Visayan dialect of Negros as *bunga*, and *bulac sang tubo*.

Mr. Federico P. Goseco who discovered this plant growing in association with sugarcane plants early in July, 1931, at the Hacienda de Agua, La Carlota, Occidental Negros, suspected it to be a parasite like *Aeginetia indica*, another Philippine representative of this family. The possibilities of the spread of this plant and its infestation of cane fields warranted a more critical study of its habit and habitat. A good number of sugarcane hills with the *Christisonia Wightii* attached had been dissected very carefully, and the plant in question was found to be a parasite. Observations made in the field showed that this parasite is not as destructive as the other root parasite (*Aeginetia indica*) of sugarcane. It is, however, found best that once this parasite is discovered in a clump of sugarcane the particular hill should be dug up right away. The parasite causes yellowing of the leaves first, but later completely kills the plant, drying it.

[1] Received for publication June 26, 1940.

OROBANCHACEAE

Genus CHRISTISONIA Gardiner

Christisonia Wightii Elmer

Christisonia Wightii Elmer in Leafl. Philip. Bot. 8(1915) 2793; Merr. Enum. Philip. Fl. Pl. 3(1923) 448.

The original description is as follows:

Terrestrial and saprophytic, succulent; stem erect, short, solitary or usually few-branched and much winged toward the top; 5 cm long, occasionally forming clumps; 1 cm thick, striate, glabrous, dirty yellowish white or brown, the longer curved, enveloped with similarly colored and glabrous imbricating scales of diverse sizes and shapes; bracts or scales toward the base short and scattered, those at the top much longer and well imbricated; branches commonly 3, arising from near the same place toward the distal end of the short thick stem, all densely surrounded at the base by numerous broadly oblong scales, very short and equally provided with imbricating scales especially toward their distal ends which bear either one or more terminal and erect flowers. *Flowers* odorless, protruding above the humus ground layer; *bract* subtending the calyx 1.75 cm long, 1.25 cm wide, coriaceous, glabrous, elliptic in outline, chiefly covering over the upper side of the calyx; *calyx* dark yellow or brownish, succulent, glabrous, subterete, nearly 2.5 cm long, 7.5 mm thick above the middle, a trifle narrower at the base, throat oblique and well slit open from the lower side, the upper end very broadly toothed, lateral teeth smaller, the lower end minutely lobed or not at all, early decaying or withering and forming a slimy dirty watery mass; corolla white especially on the interior except a rather conspicuous blotch in the lower corolla segment; 9 cm long, 5 mm thick toward the base, gradually inflated toward the very oblique throat, protruding above the humus covered foliage on the ground, curved above the middle and always facing down hill; fleshy, 1.5 cm across the throat, glabrous; segments about 5, subequal, 2.5 cm across when in full anthesis, rotately spreading, suborbicular; stamens apparently as many as corolla lobes, *included*; filaments glabrous, ribbon-like adnate except their distal ends above the middle of the corolla; anther block-shaped, 3.5 mm long, subbasifixed; pistil glabrous, nearly 5 cm long; ovary ellipsoidly elongated upon a concrete base; style subterete, equalling the corolla tube; stigma composed of 2 broad and fleshy lobes; ovules indefinite, dark brown, divided into 2 general masses.

Type specimen number 9510, A. D. E. Elmer, Dumaguete (Cuernos Mts.), Province of Negros Oriental, Negros, March, 1908.

Collected from rich damp ground among the tussocks of *Amomum fusiforme* Ridl. along the upper edge of a deep ravine at 1,750 feet altitude. "Satagbak" in the Visayan dialect.

In *Zingiberaccae* a botanist must know how to unearth the flowers or fruits of certain species in the field. In this case the collector thought these flowers represented a wild species of ginger, so I was particular to locate its leaf-bearing stems. Quoting from my field label,—"The clumps seem to lie loose in the fertile soil beneath the humus covering

and no connection was found with other living plants." A specimen was, however, sent with my other *Zingiberaceae* to *Dr. Ridley* for determination and who pronounced it a species of *Christisonia.* It is then dedicated to *Robert Wight* who figures a number of species of this saprophytic genus in his Icones Plantarum IV. It is here for the first time reported from the Philippine Islands."—ELMER, l.c.

LUZON, Bontoc Subprovince, Bauco, *M. Vanoverbergh 798, 1301,* in forests, altitudes 1290 to 1680 meters: Benguet Subprovince, Bugias, *E. D. Merrill 4656,* in deep steep banks, flowers fragrant; Baguio, *For. Bur. 5098 H. M. Curran:* Bataan Province, Limay, *Bur. Sci. 6173 C. B. Robinson:* Rizal Province, along the Pililla-Mabitac trail, *Bur. Sci. 11942 C. B. Robinson,* in sand besides streams in remains of bamboo formation, altitude 250 meters: Laguna Province, Calauan, *Bur. Sci. 12472 R. C. McGregor,* on a hill growing on bamboo clumps; Mt. Maquiling, *W. H. Brown, s. n.,* in the woods, altitude about 700 meters; Mount Banajao, *For. Bur. 8030 H. M. Curran & M. L. Merritt:* Tayabas Province, Mt. Malarayat, *For. Bur. 7828 H. M. Curran & M. L. Merritt,* altitude about 900 meters. NEGROS, Oriental Negros Province, Dumaguete (Cuernos mountains) *A. D. E. Elmer 9510* (type), March 1908: Occidental Negros Province, La Carlota, *F. P. Goseco, s. n.* November and December 1931, growing in clumps of sugarcane plants. MINDANAO, Lanao Province, Camp Keithley, *M. S. Clemens 1011,* April 16, 1907, growing in damp, slippery soil on the upper margins of the forested slopes, altitude about 800 meters. This parasite has also been observed in sugarcane fields in Salamanca, de Agua, Fe, Caiñaman, Monserrat, and Carmen Grande, all in Occidental Negros Province.

The additional descriptive data are based upon living plants sent in by Mr. Goseco.

The plant is perennial and leafless, growing vigorously and often encircling the sugarcane clumps. The stems are from 2 to 10 cm high, branched, the branches up to 5. The racemes are few-flowered, terminal and short. The flowers are fleshy, from 6 to 7 cm long. The calyx is tubular, spathose, 5-fid, 4 to 4.2 cm long, 1.7 to 1.8 cm in diameter. The corolla is funnel-shaped, wide at the mouth, 4.5 to 5 cm long; the lobes 5, suborbicular, the superior 3 large, the two inferior ones smaller. The stamens are four, the two are spurred, and the other two spurless; the spurs fleshy, curved. Capsules 2-valved, the placenta fleshy. Seeds very minute, numerous, oblong, testa pitted.

After anthesis and ripening of the seeds, a mucilaginous, sticky substance is found between the calyx and the corolla tube, the corolla tube decaying first. The bracts are corinthian red, the corolla tube is white or massicot yellow, the throat of the tube within is empire yellow, the lobes are lavender violet or mauve, the rim amethyst purple. The ovary is white, as are the style and stigma. The calyx is alizarine pink or jasper pink, in some cases almost white, particularly in the case of those buried in the soil.

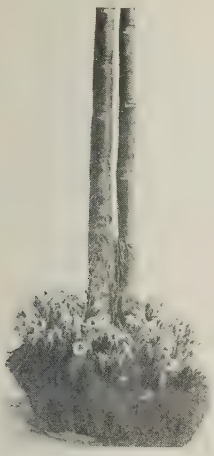
ILLUSTRATIONS

Plate 1

Fig. 1. Habit, very much reduced.
2. Habit at base of a stem of sugarcane, reduced.
3. Flowers, reduced.
4. The parasite roots and sugarcane roots: p. parasite; s. sugarcane.

Plate 2

Fig. 1. Opened and unopened flowers, reduced.
2. Flower, viewed from above, natural size.
3–4. Longitudinal section of a flower, showing calyx, corolla, pistil and two stamens, × 0.05.
5. Detail of two stamens, one with the spur, × 2.
6. Transverse section of ovary, × 7.
7. Seeds, very much enlarged.



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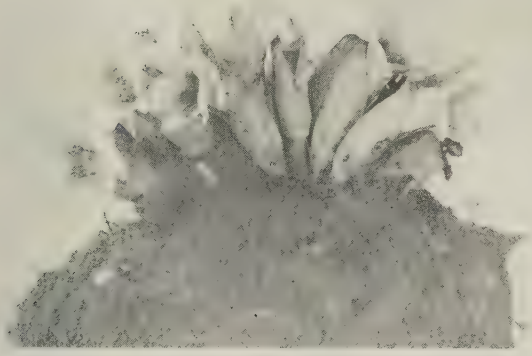

PLATE 1

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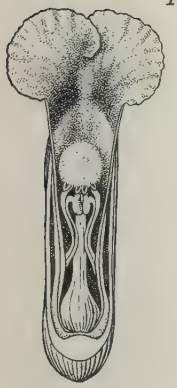

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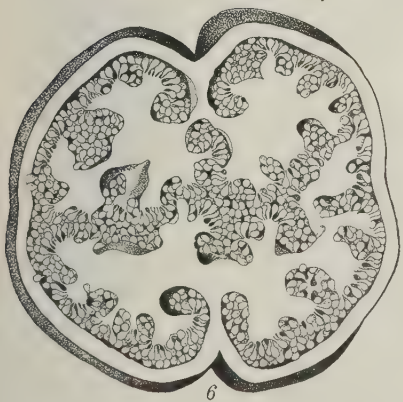

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PLATE 2.

INSECT AND OTHER PESTS OF CORN [1]

By Faustino Q. Otanes and Leopoldo T. Karganilla

Of the Plant Pest and Disease Control Division
Bureau of Plant Industry

EIGHT PLATES

The main object of this work is to bring together such available information so far, published and unpublished, about the insect and other pests of corn in the Philippines as is believed to be of value as a guide to fieldmen of the Bureau of Plant Industry and others engaged in agricultural promotional work in their efforts to aid farmers towards minimizing the ravages of such corn enemies. The emphasis being given to the production of food crops makes the need for this work the more urgent.

Incidentally, this paper gives an idea of the present status of our knowledge of insects, in particular, infesting corn. Indeed more investigational or research work has yet to be done with the object of finding out more about the biology or life-history of such insects, with due consideration to the climatic and other factors in different localities, as a basis for the search for practical and effective control measures. Pending further studies, the writers have ventured in certain cases to give suggestions with the thought that these may be of value to farmers towards lessening, to a certain extent, the ravages of the pests that attack their corn crops.

GENERAL CONSIDERATIONS

All plants are susceptible to the attack of one pest or another and corn is not an exception. No part of the corn plant is free from attack. There are as yet no estimates as to the value of the total annual damage caused by corn pests, but it may be said that the amount is by no means small. Reports of almost total destructions of corn plantings by corn borers, armyworms, corn earworms and rats are often received by the Bureau of

[1] Received for publication March 26, 1940.
[2] To be reprinted as popular bulletin No. 18.

Plant Industry. Serious destructions by the corn silk beetle have also been reported. Besides the direct injuries caused by these and other insects to corn, it is also suspected that some of them, more particularly the sucking insects, such as corn leaf aphid and the corn leaf hopper, are known to be instrumental in the transmission and spread of corn diseases.

In this work, the pests of corn are grouped and discussed as follows:

Pests	Parts damaged
A. *Pests of corn in the field:*	
a. Insect pests	
1. Migratory locust (*Locusta migratoria manilensis* Meyen)	Leaves and stalks.
2. Corn borer (*Pyrausta nubilalis* Hubn.)	Tassels, leaves, stems and ears.
3. Corn earworm *Heliothis armigera* Hubn. (*Chloridea obsoleta*)	Unfolded leaves, tassels, silk and ears.
4. Corn silk beetle (*Monolepta bifasciata* Hornst.)	Silk.
5. Cutworms and armyworms Grass armyworm (*Spodoptera mauritia* Boisd.) Common cutworm (*Prodenia litura* Fabr.) True armyworm (*Cirphis unipuncta* Haw.) Spotted cutworm (*Agrotis* sp.)	Leaves, whole plants when young.
6. Toy beetles (*Leucopholis irrorata* Chevr.)	Roots.
7. Corn leaf hopper Lantern fly of corn (*Peregrinus maidis* Ashm.) "Fulgorid" (*Proutista moesta* Westwood.)	Leaves, and tender stalks.
8. Corn leaf aphis (*Aphis maidis* Fitch)	Young leaves and tassels.
9. Corn thrips (*Frankliniella williamsi* Hood)	Leaves.
10. Corn leaf miner (*Agromyza* sp.)	Leaves.
b. Other pests	
1. Rats, wild hogs and monkeys.	Ears.
2. Parrots and crows.	Ears.
B. *Insect pests of stored corn:*	
1. Corn weevil (*Calandra oryzae* Linn.)	
2. The grey moth or Angoumois grain moth (*Sitotroga cerealella* Oliv.)	

THE ORIENTAL MIGRATORY LOCUST (*LOCUSTA MIGRATORIA MANILENSIS* MEYEN)

The Oriental Migratory Locust is one of the most important enemies of corn, as well as of rice and sugarcane. In fact it is the most important enemy of these food crops whenever there is a serious outbreak. The insects cause damage to corn in two ways:

1. Direct damage by the adults or flyers and hoppers to the crop.
2. Delayed planting of corn. Whenever locusts are rampant the farmers delay the planting and some do not plant at all.

For these reasons, the yields of corn in infested localities are reduced and accordingly many families suffer from want.

Life history and habits.—In common with other migratory locusts in other countries, the Oriental Migratory Locust has three phases in its life history, namely, phase *solitaria*, phase *transiens*,[1] and phase *migratoria*, which differ more or less in appearance and habits. During periods when there are no migratory swarms in any populated or cultivated area, the insects are known to exist as solitary locusts (phase *solitaria*), like ordinary grasshoppers (plate I, figs. 1 and 2). When conditions are unusual these solitary locusts begin to multiply into more or less thin or loose swarms. The individual insects (sub-phase *congregans* of the phase *transiens*) composing such swarms vary in color—some are green, others are brown and still others resemble the hoppers of the migratory phase, which are black and brick red in color. After a number of generations, the progeny acquire the migratory appearance and habits (plate 1, figs. 3 and 4). The more numerous the insects become, and as different groups come together to form larger aggregations, the stronger or keener the migratory instinct or impulse becomes and migrations to cultivated areas take place. This explanation of the origin of locust outbreaks is in accordance with the "phase theory" of Doctor B. P. Uvarov, of the Imperial Bureau of Entomology, London, England. Studies conducted in many countries, including the Philippines, show that the "phase theory" is the most logical explanation for the origin of outbreaks.

The Oriental Migratory Locust breeds in the uncultivated grasslands, of which there are extensive areas. Records of the

[1] The phase *transiens* has two sub-phases: *congregans* and *dissocians*. All of the progeny developing toward the migratory phase (*migratoria*) are of the phase *congregans;* those toward the solitary, *dissocians* (FQO).

old Bureau of Agriculture and its successor, the Bureau of Plant Industry, appear to show that the main breeding ground or outbreak area of the pest is found in Cotabato. Records also show that the outbreaks of the pest in the Philippines occur from 7 to 13 years, the average being about 10 to 11 years. Each outbreak usually persists for years. It reaches its maximum intensity within a certain year, after which it begins to decline. Owing to several factors, namely, the extensive campaigns waged, natural enemies, etc., the much reduced swarms tend to scatter and produce progeny (sub-phase *dissocians* of the phase *transiens*) culminating in the production of the solitary phase. Mostly individuals of this phase are therefore found between outbreaks. This temporary freedom of the cultivated areas from migratory swarm infestation may last for one or two years, after which another outbreak appears, which may again persist for years, the number depending partly upon the efforts exerted toward combating the pest. Thus the 1932 outbreak lasted only 7½ years, that is, until June, 1939. Since the average duration of outbreaks in the Philippines is 10 to 11 years, the duration of the 1932 outbreak had been curtailed by 2½ to 3½ years. For the first time too, so far as known, swarms had succeeded in reaching only Southern Luzon. In all other previous outbreaks, so far as known, the entire Philippines was invaded. This is apparently largely due to the extensive campaigns that have been waged, which were made possible by the larger appropriations that were given by the Government and to the wider application of scientific methods of control, particularly spraying with powdered soap solution and the use of poison baits, especially in the isolated areas.

The eggs of the locusts are laid in masses in holes in the soil made by the female. Each egg mass is covered with a white frothy substance which appears to serve as a protection from too much moisture in the soil and perhaps also from natural enemies. The eggs, which are yellowish brown or of the color of cheese, cucumber- or sausage-shaped, about 5 millimeters long and 1 millimeter in diameter, hatch normally in from 12 to 25 days.

The newly hatched hoppers are about 8 millimeters long and about 3 millimeters at their greatest width and are whitish upon emergence. They soon become dark in color. They molt five times and after each molt the migratory or gregarious color of the nymphs, which is black and orange or brick red, becomes more pronounced. The full-grown hoppers attain a length of

about 3.5 centimeters and a width of about 0.8 centimeter. The duration of the hopper stage, according to laboratory records, varies from 36 to 66 days. The duration of development from the time the eggs are laid to that when the hoppers change to adults is from 47 to 83 days.

The locusts begin to mate 22 to 34 days after emergence and the females commence laying eggs in one to two weeks after mating. A female may lay as many as 7 egg masses with a maximum total of over 500 eggs. Both males and females have been found to live as long as three months or over.

The period of development of the Oriental Migratory Locust may be summarized as follows:[2]

Egg stage	12 to 25 days
Hopper stage	
1st instar	6 to 10 days
2nd instar	6 to 9 days
3rd instar	6 to 14 days
4th instar	7 to 17 days
5th instar	11 to 16 days
Total for hopper stage	36 to 66 days
First mating	22 to 34 days, after the emergence of the adults.
First egg laying	7 to 14 days, after first mating.

According to these records the duration of development of the insects from the time the eggs are laid to that when the hoppers change to adults varied from 48 to 91 days.

Control measures.—In the control of locusts the following control measures are employed:

1. Catching the flyers with nets and driving the hoppers into pits. These methods are effective especially in more or less well populated provinces and where the people comply strictly with the provisions of the Locust Act (No. 2472).

2. Spraying the hoppers with solutions of ordinary soft yellow laundry soap or powdered soap. The amounts ordinarily used are from 200 to 300 grams per petroleum canful of water. A bucket pump provided with at least 5 meters of rubber hose and with a good nozzle that will deliver the spray in a fine mist may be used for spraying.

3. Dusting with calcium arsenate, either alone or mixed with starch, such as "gaogao" or other fine carrier. Derris powder with a rotenone content of 2 to 4 per cent has been found deadly

[2] As these observations or records were made on insects taken from swarms, they must necessarily refer to the insects in the phase *migratoria* and also to others possessing characters of the phase *transiens* (FQO).

to both flyers and hoppers. This may be used if it can be manufactured in large quantities.

4. Application of poison baits. Bagasse bait, prepared as follows has been found especially attractive to hoppers:

Fine bagasse	4 petroleum canfuls
White arsenic or Paris green	1 salmon canful
Molasses (mixed fifty-fifty by volume with water)	Enough should be added until the mixture is uniformly and moderately moist.

The bagasse and white arsenic or Paris green should be mixed thoroughly before the molasses is added. Instead of bagasse, sawdust or fine rice chaff may be used.

Factors essential to success in locust control.—1. More civic spirit and better compliance, on the part of the people, with the provisions of Act No. 2472, otherwise known as the Locust Act.

2. Wider application of the scientific methods of control, such as the use of arsenical dust, derris dust and poison bait.

3. More financial outlay for the control of locusts at the sources, that is, in their breeding grounds or outbreak areas especially in Cotabato and Davao, Mindanao, in order to prevent, if possible, the formation of large swarms or at least minimize the swarms that invade cultivated and populated areas. The locust menace or evil should be combated at its very root, so to state. With more funds, such work as reforestation, afforestation, introduction, protection and multiplication of natural enemies of the locust, etc., which may lead to permanent control, can be properly attended to. Fundamental investigations on the biology and ecology of the insect, especially in the breeding or outbreak areas, as a basis for predicting outbreaks and for the timely application of appropriate control measures, can also be tackled in a detailed and systematic manner.

THE CORN BORER (*PYRAUSTA NUBILALIS* HUBN.)

This insect is not only serious to corn in the Philippines but also in other countries. It is widely distributed, having gained entrance and foothold in the United States, where at one time as much as $10,000,000 was appropriated for its eradication. Large sums are still being spent there annually for control and research work in which a large staff of technical men is employed. Although the insect is widely distributed in the Philip-

pines and is likewise destructive in this country, it has not received the attention that it deserves.

Injury.—The most important and most serious injury to the corn plant is the tunnelling and the feeding of the larvae within the stalks, ear stems and ears. The tassels, the midrib of the leaves, the brace roots and the stubbles are likewise tunnelled. Newly hatched larvae feed slightly upon the tender blades and also in between the leaf sheaths and stalks.

DESCRIPTION AND LIFE HISTORY

The eggs (plate 2, fig. 1).—The eggs are flat, oval-like, shiny and are laid in a fish scale-like arrangement on the underside of the corn leaves. Newly laid eggs are pale yellow, but gradually change to brown and finally to black when about to hatch. In Manila, the eggs were found to hatch in from 4 to 6 days.

Larva or caterpillar (plate 2, fig. 2).—The newly hatched larvae are pinkish, with black or brown head and dark semicircular spots on the body, and are about 2.5 millimeters long. The full-grown larvae are creamy and dirty white, and are spotted with numerous small, brown, semicircular spots. Records of breeding work conducted in the Entomology Laboratory of the Bureau of Plant Industry in Manila during 1937 and 1938 gave 18 to 41 days for the duration of the larval stage.

Pupa (plate 3, fig. 3).—The pupa is spindle-like, with the body tapering posteriorly. The general color varies from light brown to dark brown. The most posterior segment bears two slender spines which constitute parts of the cremaster. The pupal period was found to range from 5 to 12 days.

Adults (plate 2, figs. 4 and 5).—From the anterior end of the head to the posterior tip of the abdomen, the male moth (fig. 5) is about 13.5 millimeters long and is slender, while the female (fig. 4) is about 14.5 millimeters long and is robust. The general color of the male varies from pale brown to dark brown, while that of the female is quite variable, with different shades from pale yellow to light brown. The distal or apical third of the forewing of the male is usually crossed by two narrow zigzag streaks of pale yellow. Both the forewings and hindwings of the female are also crossed by two zigzag lines darker than the rest of the wing.

Control measures.—The control of the corn borer has always been a serious problem to farmers, because of the difficulty met

once the caterpillars have tunnelled into the different parts of the plant. The following methods of control, which are in the main, preventive, are suggested:

1. The corn field should be visited often and all infested plants should be cut or pulled out and destroyed or fed to livestock.
2. All corn stalks in the fields should be disposed of as soon as the ears are harvested, either by burning or feeding them to livestock.
3. All stubbles should be pulled out and burned or plowed under deeply.
4. High yielding corn varieties should be chosen for planting.
5. Other things being equal, the most resistant or least susceptible corn varieties should be planted.
6. A system of crop rotation, which should include the growing of legumes as a means of adding fertility to the soil, should be planned and practised.
7. Fertilizers should be used, if necessary, and all other requirements of the plants, such as cultivation, etc., should be attended to so as to produce vigorous plants, and thus enable them to withstand corn borer attack better.
8. Dusting corn plants periodically with calcium arsenate may be resorted to, but in using chemicals the cost of application and probable profit should be carefully figured out before they are employed. If possible, the Bureau of Plant Industry or its field agents should be consulted before any insecticide is used.
9. The corn borer is attacked by several parasites and predators. The introduction of additional natural enemies from other countries may be tried.

THE CORN EARWORM, *HELIOTHIS ARMIGERA* HUBN. (*CHLORIDEA OBSOLETA*)

Injury.—The corn earworm is considered one of the three most injurious pests of corn in the Philippines. Although the caterpillars show a decided preference for the corn ears (hence, the name) they also attack the leaves and tassels. Newly hatched larvae begin feeding on the silk and gradually work into the developing ears and feed on the kernels and even work their way into the cobs. The injury always results in "nubbins" or poorly filled tips. The insect also infests other plants, like cotton.

DESCRIPTION AND LIFE HISTORY

The eggs.—The eggs which are laid singly on the silk are hemispherical, slightly smaller than a pinhead. They are uni-

formly light yellow just after oviposition, but are mottled with reddish brown toward the end of the incubation period, which varies from 3 to 8 days.

Larva (plate 3, fig. 1).—The larva is the only destructive stage in the life of this pest. A newly hatched caterpillar is pale, yellowish-white, with black head, and walks with a looping motion. As it approaches pupation, the body is covered with wart-like dark humps, and the color varies from pale green to very dark brown. It measures about 3.75 centimeters when full grown. Larval period varies from 22 to 28 days.

Pupa (plate 3, fig. 2).—Pupating larvae burrow six inches deep into the soil, and at the end of the burrow they change into reddish or light brown, stout shiny pupae, of about 1.88 centimeters long. Pupal period varies from 7 to 9 days.

Adults (plate 3, fig. 3).—The color of the male moth varies from light to dull olive, while that of the female is fawn-like. The forewing of the former has a dark-centered circular spot midway between the apex and the base of the costal angle of either wing, while in the latter this distinguishing character is almost absent. The hindwings of both sexes are provided with dusky bands, those of the female being broader and darker. Wing expanse is from 30 to 40 millimeters.

Control measures.—The following control measures against the corn earworm are suggested:

1. Other things being equal, corn varieties with tight-fitting and long husks should be planted.

2. Cultural measures, such as use of fertilizers, intelligent or well planned crop rotation, etc., should be practised in order to increase the fertility of the land, thus producing more vigorous plants and more crops, and thus offsetting to a certain extent whatever damage might be caused by the caterpillars.

3. In the United States, dusting the silk of sweet corn with 1 part lead arsenate or calcium arsenate and 1 part finely ground sulphur (by volume) is employed. The application should be repeated every 3 to 4 days until the silk is dry, or the ears are ready for use. This may be tried for field corn.

4. Collecting the caterpillars will help toward minimizing the ravages of the pest.

5. Light traps may also be employed against the adults. A simple light trap consists of a lantern placed over a basin of water to which kerosene has been added. Light traps should be set timely, that is, even before the ears appear so as to catch the moths before they lay eggs.

The use of poison baits for the moths consisting of sugar, sodium arsenite and water is also suggested.

THE CORN SILK BEETLE (*MONOLEPTA BIFASCIATA* HORNST.)

The corn silk beetle, as the name implies, feeds on the silk of corn ears. It has also been found to feed on the young leaves of mango, avocado, camanchili, "camoteng cahoy," and castor bean. The insects are also known to attack mango blossoms, and newly opened flower buds of gumamela. They are apparently polyphagous feeders.

Injury.—The beetles cut and eat the silk threads of the corn ears. The injury prevents pollination and few or no kernels will develop. Cases of serious injury to corn have been reported from Leyte, Bohol, Nueva Ecija, Pampanga, and other provinces.

DESCRIPTION AND LIFE HISTORY

Adult (plate 6, fig. 4).—The adult beetle is from 4 to 6 millimeters long. The elytra or outer wings are buff yellow with a dark spot at the base or cephalic end of each elytron. Another pair of dark spots, of similar color and shape, is located towards the ends of the outer wings. The life history of this insect has not been worked out.

Control measures.—1. The planting of corn should be so timed that the production of silk and tassels does not coincide with the abundance of the beetles. Such period of abundance should be carefully observed in every locality.

2. The silk threads of the corn may be dusted with lead arsenate or calcium arsenate powder early in the morning.

3. Light traps against the adults have been found to attract large numbers of the beetles. Light trapping should begin early in order to catch most of the beetles before the corn plants tassel.

4. Before the corn tassels appear, trap crops, preferably "camoteng cahoy" (*Manihot utilissima*) may be planted and insects that gather on these plants may be killed by poison spray or by means of light traps.

CUTWORMS AND ARMYWORMS (SEVERAL SPECIES)

Among the most destructive pests the farmer and the gardener have to contend with, and which may cause untold damage to crops, oftentimes resulting in the complete destruction of wide areas of crops in a single night, are the so-called cutworms and

armyworms. These pests attack many farm and garden crops. In the Philippines rice and corn are commonly attacked by these pests. The following species have been found feeding on corn:

1. Grass armyworm (*Spodoptera mauritia* Boisd.)
2. Common cutworm (*Prodenia litura* Fabr.)
3. True armyworm (*Cirphis unipuncta* Haw.)
4. Spotted cutworm (*Agrotis* sp.)

Injury.—The injury to the corn plants varies according to the age of the plants and to the degree of abundance of the caterpillars. When they are abundant the injury oftentimes results in the complete destruction of the whole fields of young corn plants. The stems are cut and the whole plants are almost entirely eaten. On older plants, that is, those plants with tassels, very little injury, if any, has been noted.

GRASS ARMYWORM (*SPODOPTERA MAURITIA* BOISD.)

Outbreaks of the grass armyworm occur almost every year. The caterpillars attack not only corn but also rice, at times destroying whole fields.

DESCRIPTION AND LIFE HISTORY

The eggs.—"The eggs are yellow, hemispherical in shape and about the size of a pinhead." They are covered with short yellowish brown hairs from the abdomen of the female and are laid in clusters on the leaves. An egg mass may contain as many as from 200 to 300 eggs, which hatch within 2 to 4 days.

Larva (plate 4, fig. 2).—The caterpillars when newly hatched are less than 2 millimeters long, but attain a length of about 5 centimeters when full grown. The general color is light or dark brown, with pale stripes on each side. When they occur in large numbers and move in large groups they have two prominent black stripes along the back. These stripes sometimes coalesce so that the caterpillar appears entirely black. They usually feed at night and become full grown in about 14 to 23 days. The feeding of the caterpillars seems to be confined to plants of the grass family.

Pupa.—The pupa is reddish brown, and averages about 1.3 centimeters in length. Pupation takes place in the ground and the adult moths emerge in from 7 to 16 days.

Adult moth (plate 4, fig. 1).—The adult is about 1.5 centimeters long with a wing expanse of about 3 to 4 centimeters,

depending upon the sex. The male is somewhat smaller. The forewings are greyish-brown, with wavy line markings, and each with a dark spot near the middle. The hindwings are whitish with dark margins.

Available records of the life cycle of the insect from the time the eggs are laid to that when the adults emerge give a duration of 23 to 43 days.

COMMON CUTWORM (*PRODENIA LITURA* FABR.)

DESCRIPTION AND LIFE HISTORY

The eggs.—The eggs are laid in clusters on the leaves of plants and also on objects on the ground. The egg masses are covered with yellowish brown hairs, but these felt coverings are sometimes wanting on eggs laid later. The incubation varies from 2 to 4 days.

Larva (plate 4, fig. 4).—The newly hatched larvae are at first all together on the food plants, but later disperse. The young larvae are greenish, each with black band about one third the length, from the head or cephalic end. Dammerman (1929) describes a full-fed caterpillar as follows:

> Dark green, with a bright yellow dorsal line and similarly colored lateral stripes, which are edged above by semi-lunar black spots.

The caterpillar becomes full grown in 20 to 46 days. The caterpillars are remarkably polyphagous, feeding not only on plants of the grass family, but also on tobacco, cauliflower, cabbage, "tangan-tangan" (*Ricinus communis*), melons, peas, etc. They are undoubtedly the most destructive noctuid caterpillars in the Philippines.

Pupa.—The pupa is reddish brown but becomes dark reddish brown when the moth is about to emerge. The wing sheaths are darker than the body. The length is about 1.6 centimeters. The pupal stage varies from 8 to 11 days, according to records obtained in Manila.

Adult (plate 4, fig. 3). The moths are about the size of that of *Spodoptera mauritia* but somewhat more robust than the latter. The forewings are purplish brown with a pattern consisting of numerous lines and spots, "while the hindwings are whitish, narrowly bended along the outer margin."

The life cycle from the laying of the eggs to the emergence of the adults varies from 30 to 61 days, according to available records.

TRUE ARMYWORM (*CIRPHIS UNIPUNCTA* HAW.)

DESCRIPTION AND LIFE HISTORY

The eggs.—The eggs are laid on grasses in the axils or protected parts of the plant. When newly laid they are smooth, shining and milky-white. They are apparently spherical, but when laid in rows, they are compressed on both sides. The incubation period varies from 4 to 5 days.

Larva (plate 4, fig. 6).—The larvae are greenish or purplish brown dorsally, but paler ventrally. Above and beneath the stigmata is a pale stripe, with a dark line running posteriorly down the middle of the back. They are nocturnal in habits, like other species. When full grown the larva measures about 4 centimeters long. The larval period lasts from 16 to 18 days, during which time the larva undergoes 5 to 6 moltings.

Pupa.—The general color is shining mahogany brown, and comparatively smooth. Pupation takes place in the ground at about ½ to 1 inch from the surface of the soil. The pupal period is about 9 to 10 days.

Adult (plate 4, fig. 5).—The moth is about 17.7 millimeters long. The forewings are yellowish-brown, with a series of black marginal spots. The hindwings are greyish-yellow, the outer margin being darker. The wing expanse is about 40 millimeters.

According to records obtained at the Entomology Laboratory of the Bureau of Plant Industry, the life cycle from the laying of the eggs to the emergence of the adults varies from 28 to 41 days.

SPOTTED CUTWORM (*AGROTIS* SP.)

DESCRIPTION AND LIFE HISTORY

The eggs.—The eggs are laid singly in rows or in compact layers on either side of the leaf, and when newly laid are transparent. They are nearly hemispherical and strongly ribbed. The incubation period lasts about 6 days.

Larva.—The larvae when newly hatched are nearly white and hairy. They are usually inconspicuous gray or brown, sometimes white, with strong green or olive brown tints. When full grown they are about 3.5 centimeters long. They undergo 4 to 5 moltings within about 18 days of their larval life.

Pupa.—The pupa is light or dark-brown. The anal segment is provided with two curved spines, and other terminal append-

ages like other noctuid pupae. Pupation takes place in the ground, lasting about 5 to 6 days.

Adult (plate 4, fig. 7).—The moth is about 15 millimeters long. The forewings are brown with numerous wavy lines. The characteristic triangular pale spot combined with two triangular black spots is present. The wing expanse is about 44 millimeters.

Control measures for cutworms and armyworms.—1. The fields should be visited often, every day if possible, and when signs of infestations are noted, control measures should at once be applied in order to prevent widespread infestation.

2. Egg masses should be collected and later crushed, or crushed on the leaves.

3. The host plants may be dusted with calcium or lead arsenate mixed with suitable carriers, such as "gaogao" or other fine starch, as suggested for the corn borer.

4. Whenever caterpillars of these pests are noticed in great numbers on nearby wild grasses and other weeds, they should be promptly killed by dusting these intermediate hosts with calcium or lead arsenate in order to prevent future heavy infestations on corn and other cultivated plants.

5. Uninfested fields could be protected by digging steep trenches around, the steep side being towards the fields to be protected.

6. Poison baits consisting of bran, white arsenic or Paris green and molasses are commonly employed in other countries against cutworms and armyworms. These may be tried under local conditions. The bait should be scattered in the evening on the ground especially between the advancing cutworms and armyworms and the field of corn to be protected. The use of sugar-sodium arsenite-water bait, as given for the corn earworm is also suggested.

7. Collecting the caterpillars will help reduce the damage especially if conducted by communities.

8. *Natural enemies.*—Cutworms and armyworms are subject to attack of insect parasites, particularly Tachina flies, certain hymenopterous insects of the genera *Euplectrus* and *Chelonus* being the most important. Small wasp parasites (chalcids) also attack the eggs.

Birds, like the "martinez" (*Aethcopsar cristatellus*) also feed voraciously on armyworms and cutworms. Everybody should coöperate with the government in the protection and encouragement of this and other insectivorous birds.

THE "TOY BEETLE" (*LEUCOPHOLIS IRRORATA* CHEVR.)

Injury.—The larvae or grubs of this insect are known to feed on the roots of various plants, such as rice, corn and sugarcane. They have also been found to attack mango seedlings, pineapple, cannas, etc. The adults or beetles feed on the leaves of mango, "santol", "ciruela", banana, bamboo, sugarcane, etc., but the mango appears to be their most preferred host.

DESCRIPTION AND LIFE HISTORY

The eggs.—The eggs are pearly white, elongate, about 2.5 millimeters in diameter. They are deposited in the soil. As they approach hatching, they become swollen and almost spherical. The incubation period is about 16 days.

Larva (plate 5, fig. 1).—The larvae are fleshy, wrinkled and normally curved. When newly hatched, they are white, but soon become light brown. The full-grown larva is pale yellow and the head, legs and spiracular plates are brownish yellow. The abdominal or hind portion appears blackish due to the intestinal contents visible through the semitransparent skin. The entire back is covered with stout, brownish and thickly set setae, but those on the ventral surface along the sides of the body are longer, but weaker and quite sparse.

Pupa (plate 5, fig. 2).—The pupae, measuring about 3 centimeters long, 1.6 centimeters wide and 1.2 centimeters thick, are brownish yellow, shiny, especially the thorax, wing pads, and the legs. The segments and the spiracles are very distinct.

The life cycle of the toy beetle is about a year in places like Manila and neighboring provinces and in Central Luzon. The beetles begin to emerge during April or May, after the first heavy rains. Emergence may even occur during March. In Occidental Negros there are apparently two broods—the November– December and the April– June broods.

Adult (plate 5, fig. 3).—The adults are glossy and blackish with a reddish tinge. The body, legs and elytra are closely pitted. The sexes are very similar in appearance, but the male is usually smaller than the female. The sexes can be more accurately distinguished, however, by means of the tibial spurs—those of the males being more slender and sharp pointed while those of the females are broader towards the end (spatulate).

Control measures.—1. Collecting the grubs while the land is being prepared. During the plowing of the land, many of them are exposed by the plow. They should be collected and killed.

2. Chickens are very fond of the grubs, so they should be permitted to roam all over the fields during cultivation or plowing. Birds, like crows, are also fond of the grubs. They should be allowed to follow the plow.

3. Adults feed on the leaves of various trees, especially mangoes. By shaking these trees the beetles are dislodged and fall to the ground. They should be collected and killed. Collecting the beetles should be done by communities to obtain the best results. This should be started early as soon as the beetles are on the wing during the months of April to June, so as to prevent as much as possible the laying of eggs. If the collection is done late, many beetles will have laid most or all of their eggs.

4. Digging around dying or wilting plants and collecting the grubs, so as to protect uninfested plants.

5. Encouraging the propagation of wasp parasites, one of them being *Campsomeris aurecollis*. This may be done by allowing nectar-bearing shrubs or bushes, like "sentimiento" (*Stachytarpeta jamaicensis*) to grow around the borders of fields and along fences for the wasps to feed on.

There are other species of grubs that commonly feed on the roots of plants of the grass family, including corn, sugarcane and rice. These may also be controlled by the application of the afore-mentioned control measures suggested for the toy beetle.

THE CORN LEAF HOPPER (*PEREGRINUS MAIDIS* ASHM.)

Leaf hoppers often attack corn. They seem to prefer young and succulent plants, as very little injury to corn plants with tassels has been noted.

Injury.—The punctures made by this sucking insect appear as small white spots with tiny drops of juices around them. Injury first appears on the upper surface of the midrib near its junction with the stalk. Infestations oftentimes spread to the unfolding buds, and to the partially open shucks of the stalks.

Besides the direct injuries caused by the corn leaf hoppers, there is the possibility of their serving as carriers or vectors of maize diseases or that, through the injuries caused, they facilitate the infection by such diseases.

DESCRIPTION AND LIFE HISTORY

The eggs (plate 7, figs. 1, 2, 3).—The eggs are small, white, and flask-shaped. They are laid, several together, in longitudinal slits on the upper surface of the leaves, usually near the

stalks. They may also be laid on the inner surface of partially open shucks on the stalks, but very rarely are laid in the tender stalk.

Nymph (plate 7, fig. 4).—Newly hatched nymphs travel down the leaf to the stalks, and according to Thomas (1913) they develop in the moisture at the base of the leaf. The nymphs are generally yellowish, somewhat mottled black. The eyes are dark red and the antennae bear short arista. When they are disturbed, they move with a quick sidewise motion. There are five (5) moltings during the 16 days of nymphal period.

Adult (plate 7, fig. 5).—The adult hopper is about 9.375 millimeters long, greyish-green with large semitransparent membranous wings, with black markings at the tip. The forewings are yellowish.

Another species of related insect, *Proutista moesta*, which is a fulgorid (Family Derbidae) is quite common on corn and sugarcane, but the damage is not usually serious as to require control. The insect is suspected as a possible carrier of corn and sugarcane diseases.

DESCRIPTION AND LIFE HISTORY

The eggs (plate 6, fig. 2).—The eggs are oval, brownish-yellow, and are reticulated. They measure about .013 millimeter long, and .009 millimeter wide. The incubation period varies from 9 to 11 days.

Nymph (plate 6, fig. 3).—A newly hatched nymph is generally light brown with deep red eyes, located on the dorso-lateral side of the head. The head is blunt on the tip while the abdomen tapers posteriorly. One-day old nymph is about .046 millimeter long and .0205 millimeter at its greatest width.

Adult (plate 6, fig. 1).—The adult is very striking and peculiar, because of the vertical position of the wings when the insect is at rest. The forewing is blue-black with light spots, while the hindwing is dark. Up to this time very little is known of the breeding habits of this insect. Dammerman claimed that Muir had found the nymphs living on decaying wood.

Control.—Whenever the injury is sufficiently serious to demand application of control measures, spraying with soap solution alone or with derris or nicotine sulphate is suggested.

THE CORN LEAF APHIS (*APHIS MAIDIS* FITCH)

The corn leaf aphis is a moderate sized aphid, deep green, with a conspicuous black spot at the base of each of the two protuberances (or cornicles) at the end of the abdomen.

Injury.—The insects cluster on the young and tender leaves of the corn plants, where they suck the sap of the plants. The injury may be followed by fungus attack. Seriously damaged plants droop and may wither and die.

DESCRIPTION AND LIFE HISTORY

Like other aphids or plant lice in the tropics, the corn aphid is known to reproduce parthenogenetically, that is, the females produce young without the previous intervention of the males. This process of reproduction is known as agamic reproduction. There are two kinds of viviparous or parthenogenetic females, the winged and the wingless, the former being responsible for the spread or establishment of new colonies in other parts of the host plants or in altogether new host plants. The alate or winged female is a blackish, delicate insect, with pale-greenish abdomen, and usually measures about 1.7 millimeters long. The apterous or wingless female has blue-green body, with black head, antennae and legs. It is slightly larger than the winged form, being about 2.3 millimeters long.

Control measures suggested.—The insects are not usually abundant as to cause widespread damage. This is partly because of their natural enemies, such as ladybird beetles and larvae of syrphid flies. However, should they threaten to become habitually numerous and destructive in any locality, attempts should be made to kill them when the infestation is as yet localized. This can be done by spraying the infested plants with soap solution with derris or nicotine sulphate.

THE CORN THRIPS (*FRANKLINIELLA WILLIAMSI* Hood)

A species of thrips (*Frankliniella williamsi* Hood) has been found infesting corn. Although thrips may be considered minor pests of corn in most places, serious destructions have been reported from Ilocos Sur and Batangas. Thrips, however, appear to be chiefly serious on corn that is planted late so that it suffers from dryness when the dry season sets in.

Control measures.—Should the degree of infestation be such that control measures are necessary, spraying with soap solution and nicotine sulphate or derris powder is suggested.

THE CORN LEAF MINER (*AGROMYZA* SP.)

A minor pest of corn is a small fly, the larvae of which have been observed to mine the leaves. It being a very minor pest, no control measure is suggested here. The larvae are mostly

parasitized, which probably accounts for the insect being a minor pest.

OTHER PESTS OF CORN IN THE FIELD

Among the most common pests of corn in the field aside from insects are rats, wild pigs, monkeys, parrots, and crows. These are injurious especially to the ears.

RATS

More or less serious destructions by rats have been, and are, commonly reported from many places in the Philippines. They attack not only corn, but also sugarcane, young coconuts, root crops and others.

Several kinds or species of rats are found in the Philippines. One of these is the cosmopolitan brown rat (*Mus norvegicus* Erxl.). Another is the field rat, *Rattus mindanensis* Mearns, which appears to be identical, according to Dammerman, with one of the Malay rats, more likely *Mus rattus jalorensis* Bohn., which is found all over the Malay region and the Indo-Australian archipelago. In general appearance, these rats have long tails, skull characters resembling closely the house rats, but the lower parts are light greyish. The size averages from 17 to 21 centimeters long. This species can thrive in irrigated or nonirrigated fields and also in the forests.

1. Two kinds of poison baits—the formulas of which are given below—have been found effective by Mr. Pablo Soriano, of the Entomology Section, Plant Pest and Disease Control Division, for controlling rats:

(*a*) Strychnine poison bait.

Clean rice	1 ganta
Strychnine powder	8 grams
Sugar	⅛ cup
Salt	9 grams
Soda	8 grams
Starch	½ standard cup

All the ingredients except rice are mixed dry, after which two small cupfuls of water are added. Heat is then slowly applied until the mixture becomes a thin paste. This thickens as the heat continues. The rice is finally added, and the mixture stirred until all the grains are well coated. The mixture is dried under the sun and is applied in the infested fields, in small heaps at distances depending upon the degree of infestation. Banana leaves may be used for placing the bait on.

(*b*) White arsenic poison bait.

Clean rice	2.5 gantas (uncooked)
Fish	½ kilo

Sugar	2 cups
White arsenic	1 salmon canful
Anis oil	1 teaspoonful

The rice, fish and sugar are cooked together with enough water, over a slow fire. These should be thoroughly mixed and when nearly cooked, the white arsenic is added, and the mixture very well stirred. The anis oil is finally added. The mixture is to be applied in the fields in small lumps like the strychnine poison bait.

A simple bait which is commonly employed in the field is a mixture of cooked rice and white arsenic. This consists of about one salmon canful of rice and three or four spoonfuls (levelful) of white arsenic. To make the bait attractive cooked fish with some broth should be added.

An attractive bait is roasted shredded coconut meat. Ripe bananas may also be used. Besides white arsenic, barium carbonate and red squill preparations may also be used as poisons against rats.

2. The use of calcium cyanide or cyanogas as a fumigant. The cyanide, preferably in powder form, is introduced into the holes or burrows, which are plugged with mud after the application in order to prevent the escape of gas. Suitable pumps or blowers can be purchased from local hardware stores. Carbon bisulphide may also be used as a fumigant.

3. The value of clean culture cannot be overestimated. Piles of brush, logs, etc., should not be left in the fields, dikes and road sides, as these afford hiding and breeding places for rats. Likewise weeds and shrubs should not be allowed to grow thickly on river banks and aqueducts. All white ant mounds in rice fields or in plantations should be destroyed so as to eliminate suitable hiding and breeding places for rats.

4. The use of traps will help, to a certain extent, in minimizing rat injury.

5. Attempts should also be made to protect, and encourage the propagation of, the natural enemies of rats, such as owls, cats, etc.

WILD PIGS

Wild pigs are especially abundant and destructive near mountains and forests. Destruction to corn crops by pigs consists in the breaking of the stalks in order to get at the cobs.

Control measures.—1. The use of white arsenic for poisoning wild pigs has been suggested. Fruits or tubers such as banana, sweet potato or cassava could be used. White arsenic powder

is placed in holes bored into the food material. The holes are then closed with the pieces bored out. These poison baits should be placed in areas where the wild pigs generally enter the plantations or the places frequented by them.

2. Phosphorous compounds have also been employed against wild pigs. In Mindanao a phosphorous paste compound in cans has been reported to have given good results. This may be purchased from Zamboanga, Zamboanga, upon inquiry from the Provincial Agricultural Office of the Bureau of Plant Industry there.

3. Fences for plantations intended as a protection against wild pigs should be substantially strong. Wire fences are especially good and perhaps cheaper in the long run than wooden or bamboo fences.

4. Trapping will help toward minimizing the injury by the pigs. Various devices for trapping wild pigs are known in different localities in the Philippines.

5. Hunting wild pigs with dogs and the liberal use of shotguns will also help much toward lessening the ravages of the pigs.

MONKEYS

Monkeys are at times observed attacking corn ears. They also attack fruits, peanuts, etc.

Control.—1. Liberal use of shotguns is an effective way of lessening the ravages of monkeys.

2. Good hunting dogs will also help, at least, in scaring the monkeys away from the corn field.

3. Trapping the animals. A trap for monkeys, which is said to have given good results in some places, is as follows:

A rectangular cage or enclosure of wood or bamboo slats is built on the ground, at a place frequented by the monkeys or near the place where they usually stay. Such a cage or enclosure may be 2 to 2½ meters high, 2 meters long and 1½ meters wide. It may be made longer and wider, if desired. If it is to be a portable trap, it need not be made very big as to make transfer difficult. Through the center of the top of the cage is fitted securely a cylindrical galvanized iron entrance, half in and half out. This may be made about half a meter long and with a diameter big enough to allow the biggest monkey to get in. For bait, ripe banana fruits, corn ears or any other attractive food may be used. With an entrance as described, a monkey can easily get in, but finds it impossible to get out once in, as it cannot get hold of the upper rim of the galvanized iron entrance. In its desperation, the incarcerated monkey makes loud cries, which attract its fellows. A trap of this type can catch several or many monkeys at a time.

PARROTS

In some places in the Philippines, parrots, more especially the white ones or "parakeets" attack corn ears. When they occur in flocks they may cause considerable damage.

Control.—1. Shooting the birds with shotguns and trapping them are among the methods employed in minimizing damage by these birds.

2. Various methods of scaring away the birds, such as the use of scarecrows, noise-making devices, etc., are also employed.

CROWS

Crows are not entirely harmful. They are both carnivorous and vegetarian. Among their foods are insects, such as root grubs, beetles, locusts, etc. However, they are observed, now and then, to cause more or less appreciable trouble to corn and other crops and to poultry. Injury to corn crops consists in the tearing off of the husks of the corn ears and the eating up of the kernels. Since crows are partly insect feeders, they should not be entirely condemned. It is only when they are definitely known to be causing injuries to crops and poultry that steps may be taken to lessen their ravages.

Control.—The following control measures may be employed:

1. Shooting the birds with shotguns.

2. Scarecrows are often effective in preventing crows from infesting a corn field. Besides the use of ordinary scarecrows, hanging dead crows in the field is often done. Other contraptions such as windwheels and noise-making devices are also employed.

3. The use of poisons, like white arsenic is practical. This may be mixed with rice, fish or meat or other attractive bait.

INSECTS THAT ATTACK STORED CORN

THE RICE WEEVIL
(*Calandra oryzae* L.)

The rice weevil is a cosmopolitan insect and is considered one of the worst pests of stored grains. In the Philippines it is considered one of the two worst pests of corn. It is particularly abundant in warm countries, where it breeds continuously and destroys all unprotected grain. In the United States, this attacks rice, wheat, oats, corn, barley, sorghum, buckwheat, kafir, macaroni and other hard products, while in the Philippines destruction has been noted mostly on corn and rice.

Injury.—Injury is not only confined to stored corn, but also to maturing ears with poorly developed and damaged husks. Both the larva and the adult damage the kernel. The adults puncture the kernels with their beaks and these holes are used for oviposition. The young larvae tunnel the grains or kernels, and eat all their contents. After consuming the contents, the larvae move to other grains, and the process is continued until all the grains are infested and destroyed.

DESCRIPTION AND LIFE HISTORY

The eggs.—The tiny eggs are inserted inside the kernels by the powerful ovipositor of the mother insect. The incubation period varies from 3 to 5 days.

Larva (plate 8, fig. 2).—The larva is a short thick-set, legless grub, almost white, with brown head. There are four stages in the entire larval period, which lasts about 21 days. The pupal period lasts about 5 days.

Adult (plate 8, fig. 1).—The adult weevil has a long snout, and is generally dull reddish-brown with four reddish spots on the strongly punctured elytra.

The complete life cycle of the insect is around 35 days.

Control measures recommended.—As control measures the following may be employed:

1. All corn ears and kernels should be thoroughly dried on concrete floor, galvanized iron sheets, sawali or buri mats before storing. This will reduce the moisture content of corn below 10 per cent, which renders it practically safe from weevil attack.

2. On a small scale, all sun dried kernels should be placed inside heated empty kerosene cans, the small opening at the top of the cans soldered later. These can then be stored.

3. Varieties of corn that produce well-developed ears with tight-fitting husks should be planted, but the ears must be dried properly before storing. The natural protection offered by the husks minimizes infestations.

4. Fumigation with carbon bisulphide, using 10 to 20 pounds of the fumigant per 1000 cubic feet of room space or volume, has been found effective. As carbon bisulphide is inflammable every possibility of fire should be avoided. The gas is very poisonous and should not be inhaled.

5. A good fumigant that is not inflammable is a mixture of carbon tetrachloride (one part) and ethylene dichloride (three parts) by volume. Twelve to fourteen pounds of the mixture

are usually used for every 1000 cubic feet of room volume. Chloropicrin may also be used as fumigant, using three pounds per 1,000 cubic feet.

6. Seed corn may be stored with naphthalene to prevent infestation.

7. Ordinary lime has been suggested as a repellant against weevils. This may be mixed with grains or ears.

8. Derris powder may also be used.

THE GREY RICE MOTH OR ANGOUMOIS GRAIN MOTH (*Sitotroga cerealella* Oliv.)

Although this insect is primarily a pest of stored rice, it may be included here as it is also known to infest seriously corn grains. It also attacks other grains, including wheat. The insect appears to be of world-wide distribution.

The caterpillar (plate 8, fig. 3) is white with a yellowish tinge and attains a length of about one centimeter. It pupates in the grain. The adult moth (plate 8, fig. 4) is about a centimeter long, of a whitish yellow or buff color. The fore or front wings are fringed with hairs at the apical angle. The hindwings are grayish and likewise fringed with hairs along the hind or anal margin.

In the United States, the life cycle has been found to be about five weeks.

OTHER MOTHS

The other moths that may infest corn and corn products are the rice moth (*Corcyra cephalonica*), the fig moth (*Ephestia cautella*), the Indian meal moth (*Plodia interpunctella*) and the Mediterranean flour moth (*Ephestia kuehniella* Zeller).

Control.—The most effective method of controlling the moths, as well as other insects found infesting corn and corn products in storage, is by fumigation with the different substances already given for the corn weevil.

The installation of pipes in "bodegas" or store rooms so these can be steam-heated to a temperature of 120 to 150° Fahrenheit is also effective. Subjection of the grains for three or more hours under these temperatures will kill all insects present, including the eggs. This method is commonly employed in flour mills and grain elevators in the United States and is said to be cheaper in the long run than fumigation.

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ANONYMOUS: "The four-spotted corn silk beetle" (*Monolepta bifasciata*). Bur. Agr. Cir. 116.

ANONYMOUS: "Rice cutworms" (*Spodoptera mauritia* Boisd. and *Prodenia litura* Fabr.). Leaflet No. 15 (Published as Bureau of Agriculture Circular No. 83 (Rev.) [*See also* Phil. Agr. Rev. 18 (1925) 4: 555–557].

ILLUSTRATIONS

Plate 1

Phases of the Oriental Migratory Locust:

Fig. 1. A hopper of the solitary phase, enlarged. (Hoppers as well as adults of the solitary phase have a tendency to resemble their surroundings.)

2. An adult of the solitary phase, enlarged. (Note the color and the rather convex pronotum or hood at A.)

3. A hopper of the migratory phase, enlarged. (Note the black and brick red color in contrast to that of the solitary phase; hoppers and adults have uniform color.)

4. An adult of the migratory phase, enlarged. (Note the saddle-shaped prothorax, with a depressed pronotum at A.)

Plate 2

Stages of the corn borer (*Pyrausta nubilalis*):

Fig. 1. Egg mass of the corn borer on a leaf of corn, indicated by arrow, about natural size.

2. A caterpillar in its tunnel in a portion of a corn stalk, about natural size.

3. A portion of a corn stalk showing pupa, about natural size.

4. A female moth, about natural size.

5. A male moth, about natural size.

Plate 3

The corn earworm, *Heliothis armigera* (*Heliothis assulta* or *Chloridea obsoleta*).

Fig. 1. A caterpillar of the corn earworm showing its work on an ear of corn, size somewhat reduced.

2. A pupa, size somewhat reduced.

3. An adult, size somewhat reduced.

Plate 4

Cutworms and armyworms:

Figs. 1 and 2. An adult and caterpillar, respectively, of the grass army worm (*Spodoptera mauritia*), about twice natural size.

3 and 4. An adult and caterpillar of the common noctuid (*Prodenia litura*), about twice natural size.

5 and 6. An adult and caterpillar of another armyworm (*Cirphis unipuncta*), about twice natural size.

7. An adult of *Agrotis* sp., the caterpillars of which also attack corn, about twice natural size.

Plate 5

Figs. 1, 2 and 3. Grubs, pupae, and adults, respectively of the "toy beetle" (*Leucopholis irrorata* Chevr.), about natural size (after Otanes).

PLATE 6

FIGS. 1, 2, and 3. Adult, egg and nymph, respectively, of a sucking insect—a fulgorid (*Proutista moesta*) on corn. Adult 40 times natural size, egg 20, and nymph 40 times.

FIG. 4. An adult beetle of *Monolepta bifasciata*, which attack corn silk. Enlargement about 10 times natural size.

PLATE 7

The corn leaf hopper (*Perigrinus maidis* Ashm.). All figures redrawn from Thomas.

FIG. 1. Portion of corn leaf showing egg punctures.
2. Eggs enlarged in place in the punctures (in situ).
3. Eggs enlarged—before hatching showing eye spots.
4. Newly hatched nymph—much enlarged.
5. Adult female—much enlarged.

PLATE 8

FIGS. 1 and 2. Adult and larva of the grain weevil (*Calandra oryzae*), which seriously infests stored corn; each figure 6 times natural size.

3 and 4. Larva and adult of the rice moth (*Sitotroga cerealella*), which at times also seriously infests corn in storage; each figure 6 times natural size.

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PLATE 1.

PLATE 2.

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PLATE 3.

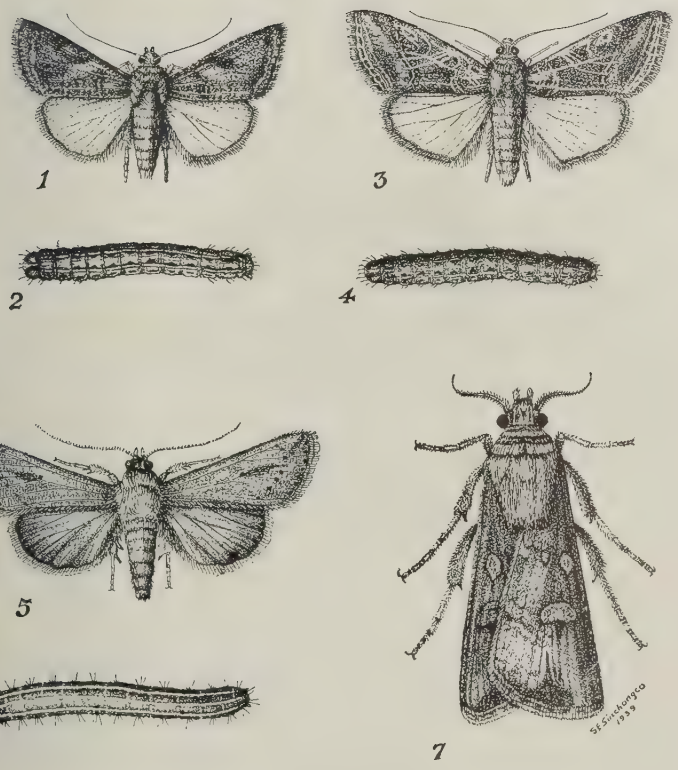

PLATE 4.

PLATE 5.

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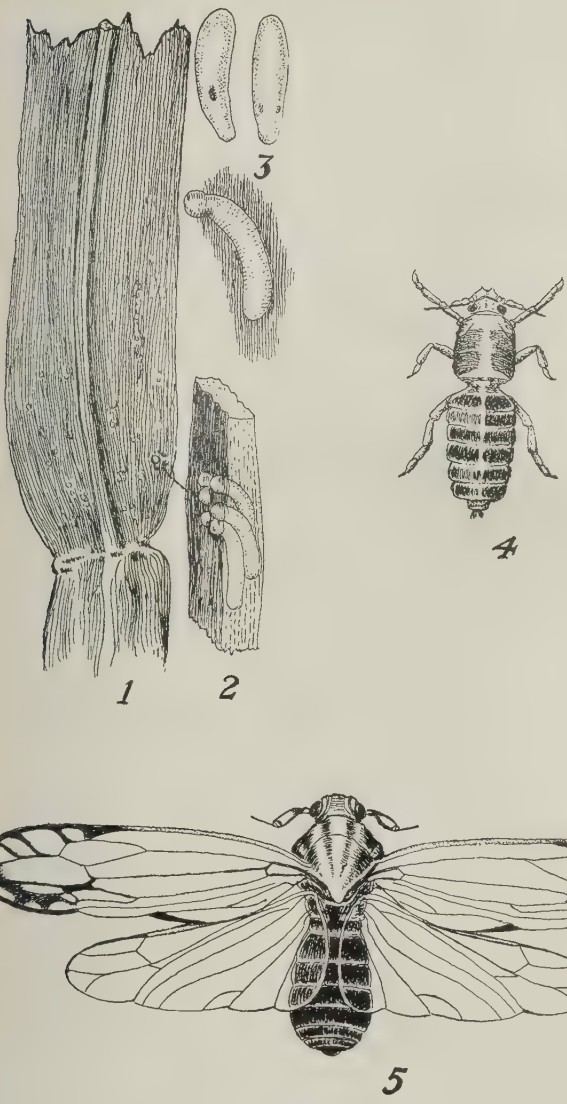
PLATE 6.



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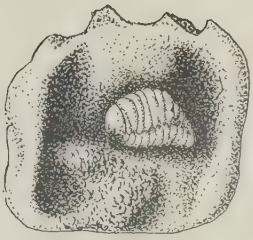

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PLATE 8.

QUARTERLY NOTES

The appointment of Mr. Francisco D. Marquez, former chief, Agricultural Extension Division, Bureau of Plant Industry as Administrative Officer, Department of Agriculture and Commerce comes as a reward to his twenty-four years of loyal service in the Government, practically all of it having been spent first with the defunct Bureau of Agriculture and, until his appointment, with the Bureau of Plant Industry.

He is familiar with many phases of our agricultural industry, being a devoted student and ardent advocate of rural improvement through improved agricultural practices and has traveled extensively throughout the Philippines.

Mr. Marquez is a 1915 graduate of the College of Agriculture, University of the Philippines. Soon after his graduation, he was made graduate assistant in the Department of Agronomy of his Alma Mater, and successively occupied positions of responsibility. Superintendent of La Carlota Experiment Station, Occidental Negros; chief of the Agricultural Extension Division, Bureau of Plant Industry since October 1, 1936 up to the time he was named Administrative Officer of the Department of Agriculture and Commerce on April 8, 1940.

He passed the first assistant agronomist examination given by the Bureau of Civil Service in 1918 (the highest agricultural examination in the government service) and was, for some time, assistant chief executive officer in the leaf-miner campaign in Laguna, Tayabas, and Batangas in 1930.

One of the Technical Consultants of the National Economic Council, member of the Philippine Technical Agriculturists Society, the Philippine Scientific Society, and the National Research Council. Also, a merit badge counsellor of the Philippine Boy Scouts, and member of the Y. M. C. A. Was executive officer of the Philippine Exposition, Department of Agriculture and Commerce participation in 1935; assistant director-general of the Pasig Carnival and Fair, 1936 and 1937.

Born of impecunious but respectable parents in Taal, Batangas, on October 4, 1893. As a student, he was self-supporting through and through, and won promotions through hard work and sheer merit.

CORRECTION

DOORDRUK voor:

DEPARTEMENT
VAN ECONOMISCHE ZAKEN
No. 1026L

Department of Agriculture and Commerce, Division of Publications, Manila.

BATAVIA (C)., *6th March 1940.*

The Director of the Bureau of Plant Industry,
Manila.

Dear Sir,

In the Philippine Journal of Agriculture, Vol. 10, No. 3, 1939, Messrs. J. P. Torres and T. G. Garrido from the Bureau of Plant Industry have published an article, entitled "Progress Report on the Breeding of Abacá (*Musa textilis* Née)", in which it is stated that Messrs. Alunan and H. T. Edwards were not allowed by the Dutch Government to visit the abacá plantations and factories in Sumatra, which caused the writers of this article to conclude, that "obviously the methods of abacá production in Sumatra are being kept secret by the Dutch Government."

In this connection I beg to inform you that the Government of the Netherlands Indies have no wish to withhold any information on this subject and is quite prepared to put the results of scientific research of the Government Research Department on this matter at the disposal of any genuine enquirers.

If Messrs. Alunan and Edwards met with a refusal to be allowed to visit certain abacá plantations and factories on the Eastcoast of Sumatra, this may be due to the fact that these plantations were private property.

As a matter of course private estates are entitled to withhold information concerning the results of their own researchwork, which often is regarded as a trade secret.

Even our own Government Officers do not always get access to information on the researchwork of private estates.

Copy of this letter has been sent to the Department of Agriculture and Commerce, Division of Publications, Manila.

Yours faithfully,

DIRECTOR OF ECONOMIC AFFAIRS,

By order:

Chief of the Agriculture Service,
w. g. (A. LUYTJES)

BUREAU OF PLANT INDUSTRY

AGRICULTURAL EXPERIMENT STATIONS AND SEED FARMS

1. Central Experiment Station, Manila.
2. Lamao Experiment Station, Limay, Bataan
3. Maligaya Rice Experiment Station, Muñoz, Nueva Ecija.
4. Lipa Citrus Experiment Station, Lipa, Batangas
5. Gandara Seed Farm, Gandara, Samar
6. Baguio Experiment Station, Baguio
7. Ilagan Tobacco Experiment Station, Ilagan, Isabela
8. Maridagao Rubber Station, Pikit, Cotabato
9. Los Baños Economic Garden, Los Baños, Laguna
10. Guinobatan Abaca Experiment Station, Guinobatan, Albay
11. Mindanao Experiment Station, Aroman, Carmen, Cotabato
12. Granja Sugarcane Experiment Station, La Carlota, Occidental Negros (under lease)

SUBSTATIONS

1. Davao Seed Farm, Davao Penal Colony, Davao
2. Kidapawan Wrapper Tobacco Substation, Kidapawan, Cotabato
3. Halcon Rubber Substation, Baco, Mindoro (under lease)
4. Abuyog Abaca Substation, Abuyog, Leyte

RESERVATIONS

1. Gingoog Lanzon Reservation, Gingoog, Oriental Misamis
2. Abaca Disease Station, Kapatalan, Siniloan, Laguna
3. Quisolon Reservation, Bukidnon
4. Bansalan Reservation, Davao

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